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IMPROVED FLAMMABILITY STANDARDS FOR THERMAL/ACOUSTIC INSULATION MATERIALS USED IN TRANSPORT CATEGORY AIRPLANES PARTS 25, 91, 121, 125, AND 135

BY

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Final Rule Regulation Evaluation

Introduction

This final rule requires new test standards for thermal acoustic insulation installed in certain transport category airplanes. The rule addresses two separate safety problems: propagation of flame on the film bags that encase insulation batting; and lack of sufficient resistance to an external fire burning through into the cabin of an airplane.[1] The FAA considered fully considered various alternatives to this final rule. One alternative was a general requirement for fuselage fire penetration resistance. Currently no FAA test standard exists to address this general requirement. If such a standard is developed the FAA may consider the general requirement for fuselage fire penetration as an alternative means of compliance. Another alternative would extend the insulation coverage to the entire fuselage for the existing fleet. The FAA rejected this alternative because of high compliance costs.

T~~T~~his final rule succeeds the Notice of Proposed Rulemaking (NPRM) published September 20, 2000 in the Federal Register. This evaluation and the evaluation of the NPRM differ in several respects. The differences are detailed below.

The FAA reviewed the comments generated by the NPRM and, as appropriate, incorporated them and follow-up clarifications into this final rule evaluation. Baseline changes have occurred since the publication of the NPRM evaluation, as follow: (a) FAA technical opinions not previously available provided a readily quantifiable engineering solution to meeting burnthrough requirements; (b) the base-year and analysis period used in the earlier evaluation were updated; and (c) the analysis was adjusted to incorporate the new FAA forecast category of regional jets. Further, continuing work on the technical issues of this rule by the FAA's William J. Hughes Technical Center, and the cost analyses of Airworthiness Directives (ADs) issued in 2000

[1] This final rule is necessary because the anticipated safety benefits do not fully accrue to the firms that will incur the regulatory cost (a market externality). From the perspective of the society this rule provides positive net benefits, while firms incurring the compliance cost will not receive sufficient benefit to justify this expense.

that required improved insulation to be retrofitted into the fleet of MD-80, MD-90, DC-10 and MD-11 airplanes provided information not available at the time of the NPRM evaluation.

The baseline changes and the additional information resulted in the benefit and cost estimates of this final rule differing from those of the NPRM in three substantive respects, as follow: (1) this final rule evaluation omits consideration of the expected industry-wide costs of apparatus used for testing to the standards required by the rule because most of these costs already have been incurred, and almost all of them were incurred by firms that pass their costs along to the affected manufacturers; (2) the rule requirements will generate insulating material and fuel-weight-penalty costs additional to those considered earlier; and (3) updates and clarifications of comments changed earlier assumptions about engineering costs, resulting in a higher estimate for configuration management. These differences are discussed in detail in the sections below on Benefits and Costs.

Technical Background

According to the Fire Safety Section of the FAA's William J. Hughes Technical Center, the function of thermal acoustic insulation in aviation is as follows:

> "Fiberglass, bat-type insulation is used extensively throughout the fuselage of commercial aircraft. It serves two main purposes: thermal and acoustic insulation. The thermal environment outside an airplane produces fuselage skin temperatures ranging from about –60º F in-flight to about 160º F when parked in direct sunlight in the desert…. However, except for a few locations (in the airplane) acoustic requirements predominate…. Insulation is used to used to attenuate (aerodynamic and engine) noise to …reasonable levels. Fiberglass batting… is a highly efficient acoustic attenuator." [2]

While this final rule does not require airplanes to be insulated, it does require insulation installed in the fuselage of certain airplanes to meet new standards. Further, although this rule does not exclude other approaches to meeting its standards, this evaluation is based on the commonly used insulating blankets. This form of insulation includes layers of material that can resist sound and/or heat (hereafter, referred to as attenuator material), a film that encases these layers, a scrim for stiffening, and an adhesive. Fabricated into blankets, these components are installed into newly built airplanes or are used as needed as replacements in airplanes already in service.

Since 1989, the FAA has been a participant in the International Aircraft Materials Fire Test Working Group, (hereafter, the Working Group) which has provided the agency a broad base of technical information about aircraft material fire test methods. Between 1993 and 1995, investigations of aviation fires involving flame propagation on thermal acoustic insulation blankets showed that some types of the thin films that encapsulate the insulating material will propagate flame. Following a 1995 fire in a MD 87 at Copenhagen, Denmark, the Working Group focused on the FAA's tests for flammability of thermal acoustic insulating material. The agency determined that a radiant panel laboratory test was effective in evaluating the in-flight resistance qualities of thermal acoustic insulation. In October, 1998, the agency announced its intention to develop new test standards and to make them mandatory. The flame propagation part of this rule follows from that announcement.

In addition to the new test standards for flame propagation, the FAA also has developed better test standards for the resistance to the burnthrough of an external fuel-fed fire into the cabin areas of certain passenger carrying airplanes. This resistance is particularly important when the fuselage remains intact following a crash. Such an accident occurred in 1985 in Manchester, England, when fuel leakage following an aborted takeoff fed a fire that burned through the intact fuselage of a B-737/200, killing 53 of 131 passengers and two of six crew members, all of whom had survived the initial impact. Over the past 20 years, at least 17 other accidents in which fuselage burnthrough may have been a factor in occupant survivability have occurred.

In its investigations of fuselage burnthrough, the FAA determined that enhancement of thermal acoustic insulation has the most potential for achieving an effective and practical burnthrough barrier. The agency based its test method on full-scale tests in which a fuselage structure was subjected to jet fuel fires, and investigated a variety of insulating materials. Test standards require a minimum of four minutes of protection against a post-crash fuel fire.

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[2] *Development of Improved Flammability Criteria for Aircraft Thermal Acoustic Insulation*, Timothy Marker, U. S. Department of Transportation, September 2000, p. one. This evaluation includes extensive unattributed quotation from this FAA document.

Because the FAA observed that fire penetrated its test rigs along seams where blankets abutted, the agency concludes that the method of installing insulating material is critical to its burnthrough resistance.[3] In fact, although FAA technical opinions have provided a quantifiable solution for use in this evaluation, the method of install~~ation~~ing ~~of~~ insulating material to resist burnthrough is not a settled issue.[4] The issue is not settled because continued research may result in lower compliance cost.

Regulatory Background

This rule will apply to 14 CFR 25, 91, 121, 125 and 135. Its application to part 25 (Airworthiness Standards: Transport Category Airplanes) will be to certain airplanes certificated after January 1, 1958. It will address two distinct conditions -- flame propagation and burnthrough -- with new test standards for insulating material, and new requirements for installing and replacing insulating material in the fuselage of certain transport category airplanes.

This rule amends part 25 to require thermal/acoustic insulation installed in the fuselage of a transport category airplane to meet the standards of a new test to determine its propensity for flame propagation. The rule also amends part 25 to require thermal/acoustic insulation installed in the lower half of the fuselage of every affected airplane with passenger capacity of 20 or more seats to meet the standards of a new test to determine its burnthrough resistance. These new tests are designed to address specific threats -- flame propagation and burnthrough -- in contrast to the tests they will replace, which focussed on the self-extinguishing characteristics of the insulation.[5]

The installation and replacement aspects of the rule will be differentially applied according to the operational service (part 91, 121, 125 or 135) under which each part 25 airplane is certificated, as explained below. These differences were chosen to ease the burden to industry and to provide the greatest net benefit to society. One such difference is the staggered compliance start date. In comparison to other possible

[3] *Development of Improved Flammability Criteria for Aircraft Thermal Acoustic Insulation, ibid,* pp. 39, 43-44.
[4] Industry Interviews, August and September, 2001. Cognizant representatives of Airbus and Boeing made this point.

compliance periods, the two and four year start dates maximize the net benefits of the rule. Earlier compliance start dates require manufacturing firms to significantly alter their flow of engineering effort resulting in substantial inefficiencies and cost increases. Delaying the effective start date marginally reduces the retrofit cost for airplanes retired in this period while postponing the benefit of the rule. As the rule is cost-beneficial, delaying the effective date reduces the expected benefit to the society.

Flame Propagation Requirements

Starting two years after the effective date of this rule, thermal/acoustic insulating materials installed in the fuselage of a newly manufactured part 25 airplane operating in part 91, 121, 125 or 135 service must meet the new flame propagation requirements. Starting two years after the effective date of this rule, for airplanes manufactured before that starting date, when any insulation blanket in the fuselage of a part 25 airplane operating in part 91, 121, 125 or 135 service is replaced, it must be replaced by an insulation blanket that meets the new fire propagation standards.

Burnthrough Requirements

Starting four years after the effective date of this rule, thermal/acoustic insulating materials installed in the lower half of the fuselage of any newly manufactured airplane operating in part 121 service, with passenger capacity of 20 or more seats,[6] must meet the new burnthrough requirements. The rule has no replacement component for its burnthrough requirement.

General Assumptions

Specific assumptions are identified as they are applied to each of the estimates that make up this evaluation. The general assumptions that guide this evaluation apply to the following:

- the period of analysis and the periods of implementation
- the physical basis of the estimate
- the economic assumptions

[5] The two requirements are not separate alternative proposals. The alternatives are to accept the rule or to do nothing.

[6] Requirements for certification under part 125 service, to which only the flame propagation sections of this rule applies, include operating airplanes that have passenger capacity of 20 or more seats or a maximum payload capacity of 6,000 pounds or more. In contrast, airplanes operating in part 121 service may have as few as 10 passenger seats.

Each of these elements is introduced in turn, as follows:

The Period of Analysis and The Periods of Implementation

The period of analysis for this evaluation is the twenty years beginning with 2002 through 2021. The reason for a 20-year period of analysis is that by the end of this period the fleet will be almost fully compliant and the annual net benefits will decline but remain positive beyond the 20th year. The base (or zero) year is 2001. Dollar values for the period of analysis are in terms of (or, are constant to) this base year. The rule is assumed to become effective in 2002. The period of implementation begins with a different start year for each requirement: 2004 for flame propagation; and 2006 for burnthrough.

Each requirement extends indefinitely into the future, past the end of the 20-year period of analysis. This evaluation considers benefits only for the portions of the periods of implementation that occur within the period of analysis. Each examined year of implementation (2004 through 2021 for flame propagation and 2006 through 2021 for burnthrough) is assumed to be equally likely to be a year during which benefits could result from this rule. The rule is assumed to generate no benefits before its requirements are implemented, and, while the FAA believes they are certain to exist, no benefits that result after the 20-year period of analysis are considered. Table A, on the next page, shows the two periods of implementation framed by (and extending beyond) the period of analysis. Certain preparatory engineering work, discussed below in the section on costs, must be completed prior to each period of implementation.

TABLE A

20-YEAR PERIOD OF ANALYSIS																					
BASE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	
18-YEAR PERIOD OF IMPLEMENTATION FOR FLAME PROPAGATION																					
2001			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	CONTINUES→
16 YEAR PERIOD OF IMPLEMENTATION FOR BURNTHROUGH																					
2001					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	CONTINUES→

The Physical Basis of the Estimates

The separate requirements of this final rule are designed to avert flame propagation accidents and to mitigate burnthrough accidents. Thus, these accidents are the basis for estimating the benefits of the requirements that will avert them. Severity and incidence are the parameters of the basis accidents.

Severity

The basis accident for estimating benefits and costs of flame propagation requirements is a catastrophic accident with the total loss of the airplane and no surviving passengers or crew. Benefits are assumed to result from averting deaths, loss of the airplane hull, and costs of an accident investigation. As detailed below in the Estimating Benefits section, this evaluation accepts a professional opinion that, if the entire fleet of affected airplanes were compliant, one catastrophic accident would be averted by the flame propagation requirements of this rule over a twenty year period.

The basis accident for estimating burnthrough benefits starts with a fuel-fed fire that follows an event, such as a minor accident, that puts the airplane in the path of the fire. The fire then burns through into the cabin of the airplane, very likely killing and injuring persons who survived the precipitating event.

Also as discussed in detail in the Estimating Benefits section, this evaluation makes use of a study that links degrees of mitigation to the severity of burnthrough accidents. The study concluded that the longer an airplane resists burnthrough, the less severe will be the effects of the accident.

This final rule is expected to mitigate – not ~~to~~ avert -- burnthrough accidents. Thus, even with the rule, likelihood exists that deaths and injuries, loss of the airplane and costs of accident investigation will result from a burnthrough accident. However, this evaluation accepts the study's estimate of the numbers of deaths and injuries that will be averted by the degree of mitigation provided by this rule. Thus, the burnthrough benefits of this rule derive from the difference in the severity of accidents without the rule and with its mitigating effects.

Incidence

This evaluation deals with three aspects of incidence, as follow:

Expected annual occurrence, which is the chance that a basis accident will be averted or mitigated during a specific year. As noted above, none of the years during the period of analysis that proceed the periods of implementation has a chance of being a year in which an accident is averted or mitigated. No year after the period of analysis is considered. Thus, expected annual occurrence follows the structure of Table A.

Within the 20-year period of analysis, each of the 18 years of implementation (2004 through 2021) of flame propagation requirements is assumed to have an equal one-in-eighteen (5.6 percent) chance of being the year the basis accident is averted. By the same reasoning, each of the 16 years of implementation (2006 through 2021) of burnthrough requirements is assumed to have an equal 6.3 percent (rounded) chance of being a year a basis accident is mitigated.

Fleet effectivity, which is the capability of the fleet to avert or mitigate a basis accident during a specific year. This capability depends on the extent the fleet is compliant with the rule. Forecasts of the annual deliveries provide the compliant fraction added to the fleet, by year of implementation. These forecasts are summarized in Table B, on page 9, which shows that the capacity of the fleet to avert a flame propagation accident is 7.6 percent in 2004, and rises to 99.3 percent in 2021. For burnthrough, the fraction of the fleet capable of mitigating basis accidents is 8.4 percent in 2006. It rises to 89.8 percent in 2021; and

Annual effective incidence, which is the combination of expected annual occurrence and fleet effectivity, which results in the probability, expressed as a percentage, that a basis accident will be averted or mitigated during a specific year. Annual effective incidence for each year of implementation is shown below in Table B. For 2004, a year that has a 5.6 percent chance that a flame propagation accident will be averted, only 7.6 percent of the fleet is capable of averting the accident. Thus, the annual effective incidence of averting a basis accident during 2004 is (0.056 **TIMES** 0.076 = 0.0042), or about four tenths of one percent. The year 2006 has a 6.3 percent chance of being a year that a burnthrough accident will be mitigated, but only the compliant 8.4 percent of the fleet can mitigate an accident. Multiplying these percentages produces the factor of *annual effective incidence* for burnthrough in 2006 of about five tenths of one percent.

When the annual effective incidence factor is applied to some number — one, two or N – of accidents assumed or known to occur within a span of years,[7] the result is the number of accidents the rule is expected to avert on a *per*-year basis. Thus, one flame propagation accident multiplied by the factor 0.0042 results in a four-tenths of one percent expectation of an averted accident for one year out of the eighteen year period of implementation. If three such accidents were assumed or known to occur over the period of implementation, the per-year value would be 3 **TIMES** (0.0042), or -0.013, a one and three-tenths percent expectation of averting one accident one year during the span.

[7] This factor provides a per-year value based on a value over a span of years. It is not used when per-year values are available.

TABLE B

DEVELOPMENT OF VALUES FOR THE ANNUAL EFFECTIVE INCIDENCE OF AVERTING AND MITIGATING BASIS ACCIDENTS							
Period Of Analysis	Calendar Year	Flame Prop. Annual Expected Incidence (Column a)	Burn-Through Annual Expected Incidence (Column b)	Flame Prop. Fleet Expected Incidence (Column c)	Burn-Through Fleet Expected Incidence (Column d)	Flame Prop. Annual Effective Incidence (Column e)	Burn-Through Annual Effective Incidence (Column f)
BASE	2001	-	-	-	-	-	-
1	2002	-	-	-	-	-	-
2	2003	-	-	-	-	-	-
3	2004	0.0556	-	0.0758	-	0.0042	-
4	2005	0.0556	-	0.1549	-	0.0086	-
5	2006	0.0556	0.0625	0.2366	0.0844	0.0131	0.0053
6	2007	0.0556	0.0625	0.3202	0.1709	0.0178	0.0107
7	2008	0.0556	0.0625	0.3998	0.2548	0.0222	0.0159
8	2009	0.0556	0.0625	0.4683	0.3282	0.0260	0.0205
9	2010	0.0556	0.0625	0.5339	0.3985	0.0297	0.0249
10	2011	0.0556	0.0625	0.5916	0.4615	0.0329	0.0288
11	2012	0.0556	0.0625	0.6520	0.5255	0.0362	0.0328
12	2013	0.0556	0.0625	0.7094	0.5862	0.0394	0.0366
13	2014	0.0556	0.0625	0.7678	0.6469	0.0427	0.0404
14	2015	0.0556	0.0625	0.8136	0.6965	0.0452	0.0435
15	2016	0.0556	0.0625	0.8526	0.7394	0.0474	0.0462
16	2017	0.0556	0.0625	0.8887	0.7792	0.0494	0.0487
17	2018	0.0556	0.0625	0.9168	0.8114	0.0509	0.0507
18	2019	0.0556	0.0625	0.9424	0.8408	0.0524	0.0525
19	2020	0.0556	0.0625	0.9662	0.8680	0.0537	0.0543
20	2021	0.0556	0.0625	0.9930	0.8977	0.0552	0.0561

NOTE: Burnthrough factors for expected annual occurrence are applied ONLY to averted costs of accident investigation
NOTE: Although delivery of new compliant airplanes is very likely to be spread evenly throughout the year, as opposed to all being received on the last day of the year, for consistency throughout all sections of the evaluation, this analysis uses the end-of-year compounding convention for the 7 percent present value factor.
LEGEND:
Proportion of compliant fleet derived using Greenslet's *The Airline Monitor*, July 2001, *and* Greenslet's *United States Airlines Fleet Forecast 2000 Through 2012*, December 2000

The Economic Assumptions

This evaluation takes a twenty-year look at a rule assumed to become effective in 2002, and to be implemented by parts in 2004 and 2006. The base year from which the evaluation looks forward is 2001. All estimated dollar values are expressed in terms of (set constant to) their 2001 buying power, indexed by annual changes in the Gross Domestic Product Implicit Price Deflator (GDPIPD)~~-~~[8], as advised by OMB Circular A-94. This Circular advises the use of the annual values of this series up to the end of their published forecast period (2006 for the 2001 update), and use of the last value for remaining out-years being estimated.

[8] Budget of the United States Government, Fiscal Year 2002, Table 10~~, internet address file:///C|/USERDATA/WORD/2002GDP.html~~

OMB Circular A-94 also advises using 7 percent annually as the real discount rate to produce the single present value (in terms of 2001 dollars) of the summation of all the out-years of constant dollars. This allows the decision criterion (or figure of merit) of Net Present Value to be developed by taking the difference between the present value of benefits and the present value of costs.

Estimating Benefits

Estimating the Benefits of the Flame Propagation Requirements

This rule will generate safety benefits by averting accidents involving flame propagation and by mitigating accidents involving burnthrough. Over the 20-year period of analysis examined in this evaluation, the estimated total present value of flame propagation and burnthrough benefits is about $222.6 million.

The Basis of the Estimate

When an in-flight fire that propagates on insulation in an inaccessible area is detected soon enough, diversion of the flight is likely, thus averting death, injury and damage to the airplane. This rule is designed to avert the catastrophic accident -- with 100% fatalities and the complete loss of the airplane – that can result when flame propagating on insulation in inaccessible areas is not detected until it grows beyond the capacity of the aircrew to control. Such a catastrophic accident is the basis of the estimate for estimating the benefits of compliance with flame propagation requirements. The components of this basis accident include: (a) deaths; (b) loss of the airplane; and (c) investigation of the accident. Each component will be considered in turn below.

The base-year is 2001 and the 20-year period of analysis is 2002 through 2021. The period of implementation begins with the start year 2004 and goes through 2021. Benefits are assumed to accrue only for the period of implementation.

Background

The catastrophic accident which occurred on September 2, 1998, when Swissair Flight 111 crashed off the coast of Nova Scotia, Canada, with the loss of 229 lives, is an example of the type of accident on which this estimate is based. Although the Transportation Safety Board of Canada has not released its final investigative report, on August 28, 2001, that agency issued *Aviation Safety Recommendations*, which states the following:

…The most significant material flammability deficiency discovered has been the inappropriate flammability characteristics of the MPET-covered thermal acoustic insulation blankets…"[9]

The airplane was a McDonnell Douglas MD-11. It was equipped with insulation blankets composed of fiberglass covered with metalized polyester (MPET). Although this airplane was being operated in compliance with 14 CFR 129, and thus would not have been subject to this rule, it was manufactured in compliance with 14 CFR 25 and was substantially identical to other MD-11 airplanes operated under 14 CFR 121 and 125 that are subject to this rule. Since the Swissair accident, the FAA has issued ADs that required improved insulation to be retrofitted into the fleet of MD 80, MD 90, MD10 and MD11 airplanes.

In September 2001, the Fire Safety Section of the FAA's William J. Hughes Technical Center provided its professional engineering opinion that[10]:

"…this rule change will likely prevent one catastrophic in-flight accident over a twenty-year period after implementation."

The Section supports its judgment as follows:

"During the study period from 1967 through 1998 three fatal in-flight fires occurred on part 121 carriers in North America and an additional six throughout the rest of the world in which the fire was in an inaccessible area and the thermal/acoustic film may have played an important role. A review of recent incident, accident and service difficulty reports indicate that there are between three and five in-flight fires causing serious damage on part 121 aircraft in the U.S. per year. Most of those occurrences included the spread of fire on the thermal/acoustic film. Preliminary information obtained on one accident (Air Tran Airways, DC-9-32 on November 29, 2000 at Atlanta Georgia) indicates that had the fire started a little later in the flight the aircraft would not have been able to make it back to the airport.

Given the above, it is estimated that one catastrophic in-flight fire accident will occur every ten years in the U.S. Thermal acoustic insulation film makes up a large percentage of the surface area in the inaccessible areas of airplanes. If this rule change were fully implemented, it would eliminate 50% of the annual 3 to 5 in-flight fires, thus halving the likelihood of a catastrophic accident to one in every 20 years." [11] (emphasis added)

As emphasized, this opinion assumes the fleet is fully compliant with flame propagation requirements. Because this will not be the case until after the period of analysis, the opinion of certainty that one basis

[9] *Aviation Safety Recommendations,* Transportation Safety Board of Canada, 28 August 2001, p.2. Internet Access at http://www.tsb.gc.ca/ENG/

[10] The FAA William J. Hughes Technical Center is a world-renowned aviation safety research center. A discussion of the Center's Fire Safety continuing research is available on the Technical Center web page. In addition to the years of fire safety study, the Fire Safety Section engineers were aware of a draft report "A Benefit Analysis for Enhanced Protection from Fires in Hidden Areas on Transport Aircraft." This study evaluates the potential benefits from fires in hidden areas inside the pressure shell of an airplane.

accident will be averted within the 20-year period following the implementation of the rule is restated in terms of annual effective incidence (as discussed above, and as presented in Table B). Column (d) of Table B shows the annual effective incidence of averting one flame propagation accident during the period of implementation. While the use of annual effective incidence does not produce the result of one catastrophic accident averted within the twenty year period of analysis, the FAA believes this analysis is consistent with the professional opinion on which it is based, for the following reasons: [12]

- full compliance is not expected to be achieved until 21 years after the rule is expected to become effective
- the use of annual effective incidence captures the sense of the opinion by allocating the combined chance of, and capacity for, averting an accident to each year the rule is implemented during the first 20 years including the year it is expected to become effective.

Estimating the Benefit of Averting Deaths

The NPRM evaluation was based on the assumption that the averted catastrophic accident would occur at the midpoint of the 20-year period of analysis. This final rule evaluation is based instead on the assumption of annual effective incidence described above.

For any one year of the period of analysis, the potential number of averted fatalities from the basis accident equals the average number of seats per affected airplane, multiplied by the load factor (occupancy rate) [13], plus the minimum number of flight crew.[14] This result is multiplied by the explicit escalation factor of annual rate of growth in length of passenger trips[15] to produce annual estimated exposure to risk of passengers and crew. Because lengthened passenger trips can involve changing airplanes, this evaluation assumes the escalated exposure does not extend to the airplane hulls.

The estimated annual exposure of passengers and crew is multiplied by the current FAA policy value of $3,000,000 to result in the quantified annual benefit from averted deaths.[16] The total expected value of the benefits of averting deaths over the period of analysis (2001 through 2021) is the sum of the annual expected values over the period of implementation (2004 through 2021). Discounting this sum to the base-year (2001) at

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[11] Fire Safety Section, William J. Hughes Technical Center, FAA, email and telephone communications, September, 2001
[12] Fire Safety Section, William J. Hughes Technical Center, FAA, email and telephone communications, May-July, 2002
[13] Forecast seat and load factors FAA Aerospace Forecasts for Fiscal Years 2001 – 2012. These factors are an implicit escalator.
[14] Minimum number of required flight crew is based on 14 CFR 25.1523, 121.385 and 121.391.

7 percent annually results in the present value of about $110.3 million of benefits from averting deaths by compliance with the flame propagation requirements of this rule. Table C, below, shows the details of this procedure.

TABLE C

MONETIZED BENEFITS OF AVERTING DEATHS BY COMPLIANCE WITH FLAME PROPAGATION REQUIREMENTS (IN THOUSANDS OF CONSTANT 2001 DOLLARS)

Analysis Period	Calendar Year	Forecast Avg.Number Of Pax And Crew (Escalated For Exposure)	Forecast Average Load Factor	Derived Number Of Averted Deaths *per* Accident	Annual Effective Incidence Of Averting A Basis Accident	Benefits Of Averted Deaths Monetized At $3,000,000 (Undiscounted)	7% Present Value Factor	Benefits Of Averted Deaths Monetized At $3,000,000 (Discounted)
BASE	2001	-	-	-	-	-	1.0000	-
1st	2002	-	-	-	-	-	0.9346	-
2nd	2003	-	-	-	-	-	0.8734	-
START	2004	162.4	0.758	123.1	0.0042	1555.5	0.8163	1269.7
4th	2005	164.6	0.761	125.3	0.0086	3234.4	0.7629	2467.5
5th	2006	166.5	0.765	127.4	0.0131	5022.9	0.7130	3581.3
6th	2007	168.8	0.765	129.1	0.0178	6891.5	0.6663	4591.8
7th	2008	171.5	0.765	131.2	0.0222	8741.4	0.6227	5443.3
8th	2009	174.2	0.764	133.1	0.026	10388.2	0.5820	6046.0
9th	2010	177.1	0.764	135.3	0.0297	12036.5	0.5439	6546.6
10th	2011	179.9	0.764	137.4	0.0329	13548.8	0.5083	6886.9
11th	2012	182.7	0.763	139.4	0.0362	15145.7	0.4751	7195.7
12th	2013	185.2	0.763	141.3	0.0394	16708.2	0.4440	7418.5
13th	2014	187.9	0.764	143.5	0.0427	18369.0	0.4150	7623.1
14th	2015	190.5	0.765	145.7	0.0452	19760.7	0.3878	7663.2
15th	2016	193.2	0.766	148.0	0.0474	21031.2	0.3624	7621.7
16th	2017	196.0	0.766	150.1	0.0494	22235.7	0.3387	7531.2
17th	2018	198.7	0.767	152.4	0.0509	23284.3	0.3166	7371.8
18th	2019	201.5	0.768	154.8	0.0524	24306.1	0.2959	7192.2
19th	2020	204.4	0.769	157.2	0.0537	25305.9	0.2765	6997.1
20th	2021	207.3	0.770	159.6	0.0552	26412.0	0.2584	6824.9
PRESENT VALUE OF TOTAL BENEFITS FROM AVERTED DEATHS								**$110,272.5**

LEGEND:

Money values expressed in Constant 2001 dollars

Policy value for quantified benefit of averted death from *Treatment of Value of Life and Injury in Economic Analysis*, APO-02-1, February 2002

Seat and load factor forecasts adapted from *FAA Aerospace Forecasts, Fiscal Years 2001-2012*, APO-01-1, March 2001

Exposure escalation from average annual rate of change in length of passenger trips *FAA Aerospace Forecasts, Fiscal Years 2001-2012*, APO-01-1, March 2001

Estimating the Benefit of Averting the Loss of the Airplane Hull

The quantifiable benefit of averting the loss of the hull of an affected airplane is based on two factors:

[15] FAA Aerospace Forecasts, FY 2001-2012. Annual average growth is about eight-tenths of one per cent per year.

(1) the equal chance that every year of the period of implementation has of being the year the basis accident is averted. This is the expected annual occurrence factor;

and

[16] FAA APO Bulletin 02-01, *Treatment of Value of Life and Injury in Economic Analysis*, February 2002.

(2) the varying chance that a specific year's delivery of compliant airplanes has of including the airplane the requirements will save – that year or later -- from being lost in a catastrophic accident. This is the fleet effectivity factor, the annual proportion of newly compliant airplanes.

This estimate requires a multi-step process that tracks the impact of each year's delivery of newly compliant airplanes on the fleet-wide probability of averting a basis accident. The six steps in building this estimate are these following:

(a) estimate the discounted base year hull values for each year of the period of implementation

(b) extend each base-year (delivery year) value to each out-year (save year)

(c) adjust each save year value for annual expected occurrence

(d) again adjust each save year value for annual fleet effectivity (each year's proportion of newly compliant airplanes)

(e) sum the component values (by year of delivery) within each save year

(f) sum the save year totals to find the total expected present value.

The first step involved estimating the value of the average affected airplane for the base year 2001, based on published prices for late-model used airplanes. This value, $46.2 million, was escalated (based on advice from the publisher of the prices) to and through the period of implementation, and then converted to constant 2001 dollars. These steps result in re-stating the estimates of average actual dollar airplane hull values in terms of base-year constant dollars. The constant dollar value of the average hull for each successive year of implementation was then discounted at 7 percent annually to its base year (2001) value.[17] Thus, as shown below in Column (a) of Parts I and II of Table D, the present value of the average hull built and lost in 2004 is about $39.1 million constant 2001 dollars. The present value of the average airplane delivered in 2005 is about $36.9 million. The same value for 2021 is about $14.4 million.

(a) Extending Base-Year (Delivery Year) Values to Out-Years (Save Years)

Within the period of analysis, a compliant airplane delivered during 2004 could be saved in any years of the span including 2004 and 2021; a compliant airplane delivered in 2005 could be saved in any of the years from 2005 through 2021; and so on. Part I of Table D shows each delivery year hull value (column value) distributed across its possible save years (row values). Each save year constant dollar value is discounted back to its delivery year value at the same 7 percent rate that is applied to the successive delivery year values, as shown below. For example, the present value in 2007 (in constant 2001 dollars) of an airplane that was delivered in 2004 is $32.8 million. The shaded block below shows distributed hull values <u>before</u> they are adjusted in Part I of Table D.

DELIVERY YEARS		SAVE YEARS				
		2004	2005	2006	2007	AND
2004	$39.1	$39.1	$36.9	$34.8	$32.8	
2005	$36.9		$36.9	$34.8	$32.8	SO
2006	$34.8			$34.8	$32.8	
2007	$32.8				$32.8	ON
AND SO ON						

Part I of Table D shows the effect of adjusting the values shown above for annual expected occurrence, as explained in the next step.

(b) Adjusting for Annually Expected Occurrence

Because each of the eighteen years of implementation has the same claim (about 5.6 percent) on certainty as the others, each out-year estimate must be multiplied by the annually expected incidence factor of 5.6 percent. This factor, shown in Column (c) of Part I of Table D, is applied to each of the save year values of Part I of Table D (each of which already has been re-stated in the present value of constant 2001 dollars).

For the 2004 delivery year, the cell values thus produced range from about $2.17 million (the 5.56 percent chance that an airplane valued at $39.1 million in 2001 constant dollars will be delivered in 2004 and saved by flame propagation requirements from being lost in 2004), to about $850,000 for the same airplane delivered in 2004 and saved in 2021. $850,000 is the 2021 constant dollar value discounted from 2021 back to 2004 at 7 percent annually. As an example that can be followed in Part I of Table D (by reading horizontally across the shaded row) the estimated value in constant 2001 dollars of a compliant airplane delivered in 2007 and lost in 2021 is about $840,000.

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[17] This results in an overall composite rate that includes escalation *per* Veritas' *Blue Book* staff advice, conversion to constant dollars *per* OMB and discounting at 7 percent annually *per* OMB.

(c) Adjusting for Fleet Effectivity

Each year's supply of newly effective airplanes supports only a fraction of the annual 5.6 percent certainty that a compliant airplane will be saved in that year. As column (c) of Part II of Table D shows, the fleet effectivity factor changes with each year's delivery of compliant airplanes. Thus, for 2004, the newly deliverd compliant airplanes constitute about 7.6 percent of the total fleet; for 2005, about 8.2 percent; for 2006, about 8.4 percent; for 2007; and so on. Part II of Table D shows the value of this fraction of delivered compliant airplanes after it is multiplied by each hull value in the save years of Part I.

Thus, the expected benefit of averting the loss in 2007 of an airplane that was valued at $39.1 million (in constant 2001 dollars) when it was delivered in 2004 is estimated as follows:

Constant Dollar Hull Value		Expected Annual Occurrence		Annual Fleet Effectivity		Save Year Expected Value
$32.8 Million	TIMES	0.056	TIMES	0.076	EQUALS	$0.014 Million

This example can be followed in the shaded area of Part II of Table D. The shaded area of Part II of Table D shows the result of this computation for each delivery year (2004; 2005; 2006; and 2007) embodied in save year 2007. The values shown have been multiplied (1) by expected annual occurrence and (2) by annual fleet effectivity. Thus, the present values (in constant 2001 dollars) of the adjusted delivery year values (in millions of constant 2001 dollars) embodied in save year 2007, are as shown in the shaded block below.

SAVE YEARS			
2004	2005	2006	**2007**
0.16	0.16	0.15	**0.14**
	0.17	0.16	**0.15**
		0.16	**0.15**
			0.16

(d) The Present Value of Total Expected Benefits

Part III of Table D shows the sum (as it was determined for save year 2007) for each save year. The shaded area shows the present value, discounted to the base year 2001, of the sum of the delivery year values (in millions of constant 2001 dollars) embodied in save year 2007 to be $0.6 million, as shown below.

SAVE YEARS			
2004	2005	2006	**2007**
0.16	0.16	0.15	**0.14**
	0.17	0.16	**0.15**
		0.16	**0.15**
			0.16
EXPECTED VALUE FOR 2007			**$0.60**

When the total value of adjusted embodied delivery years values is computed for each save year, and all save year totals summed, the result is about $15.6 million (in constant 2001 dollars, discounted at 7 percent to the base year) of benefits of averting the loss of an airplane hull by complying with this rule. This value is much smaller that the $39.1million present value of the average airplane newly delivered in 2004, because of the following: (1) the combined effects of annual expected occurrence and fleet effectivity; and (2) the necessity~~necessary~~ of discounting back to the 2001 base year of values estimated out to 2021. Parts I, II and II of Table D are shown on the next page.

TABLE D

MONETIZED EXPECTED VALUE OF BENEFITS OF AVERTING AIRPLANE HULL LOSS BY COMPLIANCE WITH FLAME PROPAGATION REQUIREMENTS (IN MILLIONS OF CONSTANT 2001 DOLLARS) ALL VALUES ROUNDED

PART I

ADJUSTMENT FOR EXPECTED ANNUAL OCCURRENCE

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
a	b	c	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
2004	39.1	0.056	2.17	2.05	1.94	1.84	1.74	1.65	1.56	1.47	1.39	1.32	1.25	1.18	1.12	1.06	1.00	0.95	0.89	0.85
2005	36.9	0.056		2.05	1.94	1.83	1.73	1.64	1.55	1.39	1.31	1.24	1.18	1.11	1.05	1.00	0.94	0.89	0.84	0.80
2006	34.8	0.056			1.93	1.83	1.73	1.64	1.55	1.46	1.38	1.31	1.24	1.17	1.11	1.05	0.99	0.94	0.89	0.84
2007	**32.8**	**0.056**				**1.82**	**1.72**	**1.63**	**1.54**	**1.46**	**1.38**	**1.31**	**1.24**	**1.17**	**1.11**	**1.05**	**0.99**	**0.94**	**0.89**	**0.84**
2008	30.9	0.056					1.72	1.62	1.54	1.45	1.38	1.30	1.23	1.16	1.10	1.04	0.99	0.93	0.88	0.84
2009	29.1	0.056						1.62	1.53	1.45	1.37	1.30	1.23	1.16	1.10	1.04	0.98	0.93	0.88	0.83
2010	27.5	0.056							1.53	1.44	1.37	1.29	1.22	1.16	1.09	1.04	0.98	0.93	0.88	0.83
2011	25.9	0.056								1.44	1.36	1.29	1.22	1.15	1.09	1.03	0.98	0.92	0.87	0.83
2012	24.4	0.056									1.36	1.28	1.22	1.15	1.09	1.03	0.97	0.92	0.87	0.82
2013	23.0	0.056										1.28	1.21	1.15	1.08	1.03	0.97	0.92	0.87	0.82
2014	21.7	0.056											1.21	1.14	1.08	1.02	0.97	0.92	0.87	0.82
2015	20.5	0.056												1.14	1.08	1.02	0.96	0.91	0.86	0.82
2016	19.3	0.056													1.07	1.02	0.96	0.91	0.86	0.81
2017	18.2	0.056														1.01	0.96	0.91	0.86	0.81
2018	17.2	0.056															0.95	0.91	0.85	0.81
2019	16.2	0.056																0.90	0.85	0.90
2020	15.3	0.056																	0.85	0.81
2021	14.4	0.056																		0.80

PART II

ADJUSTNENT FOR FLEET EFFECTIVITY

			1	2	3	**4**	5	6	7	8	9	10	11	12	13	14	15	16	17	18
d	e	f	2004	2005	2006	**2007**	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
39.1	2004	0.076	0.16	0.16	0.15	0.14	0.13	0.12	0.12	0.11	0.11	0.10	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.06
36.9	2005	0.082		0.17	0.16	0.15	0.14	0.13	0.13	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07
34.8	2006	0.084			0.16	0.15	0.14	0.14	0.13	0.12	0.12	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07
32.8	2007	0.087				0.16	0.15	0.14	0.13	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07
30.9	2008	0.087					0.15	0.14	0.13	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07
29.1	2009	0.08						0.13	0.12	0.12	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07
27.5	2010	0.079							0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07
25.9	2011	0.076								0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06
24.4	2012	0.074									0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.06	0.06
23.0	2013	0.072										0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.06
21.7	2014	0.069											0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06
20.5	2015	0.067												0.08	0.07	0.07	0.06	0.06	0.06	0.05
19.3	2016	0.064													0.07	0.07	0.06	0.06	0.06	0.05
18.2	2017	0.062														0.06	0.06	0.06	0.05	0.05
17.2	2018	0.059															0.06	0.05	0.05	0.05
16.2	2019	0.057																0.05	0.05	0.05
15.3	2020	0.055																	0.05	0.04
14.4	2021	0.053																		0.04

PART III

SUMS OF EXPECTED BENEFITS BY SAVE YEARS (MILLION OF DOLLARS)

SAVE YEARS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	
CONSTANT 2001 DOLLARS	0.16	0.32	0.47	0.60	0.72	0.81	0.89	0.94	0.99	1.03	1.06	1.08	1.09	1.09	1.09	1.08	1.07	1.06	**$15.6**

LEGEND:

Money values expressed in constant 2001 dollars --Rounded

Delivered airplane values for base year 2001 were estimated as advised by AVITAS staff from values presented in the *AVITAS Blue Book of Jet Aircraft Values, 2000-2020*, AVITAS, Inc., Chantilly, VA, 2000.

Composite – all fleet -- value was derived by weighting *Blue Book* values by the forecast of deliveries of airplane types/models for airplanes built in 2004, in *The Airline Monitor*, July 2001, Edmund Greenslet, Ponte Vedra Beach, FL, pp. 14-15

Escalation to and through the period of analysis based on advice from AVITAS staff.

Estimating the Benefit of Averting the Cost of an Accident Investigation

The FAA estimated the average cost of combined public and private sector components of investigating a major catastrophic accident at about $6.2 million in 2000 dollars.[18] Using the Gross Domestic Product Implicit Price Deflator, that cost is escalated to 2004 (the first year of the period of implementation), converted to constant 2001 dollars, and finally discounted to its base year (2001) value at 7 percent annually. These steps result in the present value of about $5.5 million for the cost of an accident investigation that is certain to occur during 2004.

As before, the certainty of this event occurring in this year cannot be known. Instead, its expected occurrence is determined by assuming each implementation year has an equal chance of being the year the costs of investigation are averted. Thus, each year's estimate of investigation cost is multiplied by the annual expected occurrence factor. Further, because the affected fleet becomes compliant (and thus capable of averting the costs of an investigation) year by year, starting at 7.6 percent for 2004 (as shown in Table B), each year's occurrence adjusted estimate of cost is multiplied by the fleet effectivity factor.

Applying both these factors adjusts the annual estimate of cost downward from the estimate when the cost is certain for a given year. When these adjusted annual estimates are totaled, and their sum is discounted at 7 percent annually to the base year, the estimated present value of the expected benefit of averting the cost of an accident investigation by complying with this rule is about $1.4 million in constant 2001 dollars.

Total Benefits of the Flame Propagation Requirements

The present 2001 value of the expected total benefit of complying with flame propagation requirements is about $127.3 million in constant 2001 dollars. This estimate is based on averting a single catastrophic accident, and includes the components of averted deaths ($110.3 million), averted loss of airplane hull ($15.6 million), and averted costs of accident investigation ($1.4 million).

[18] Unpublished APO Bulletin, APO-00-1, Aviation Accident Investigation Costs

Estimating the Benefits of Burnthrough Requirements

Most of the information used for estimating the benefits of mitigating burnthrough accidents came from a study of worldwide burnthrough accidents that R.G.W. Cherry & Associates, Ltd., [19] delivered to the FAA in 1999. The Cherry study was based on observations of burnthrough accidents during the period 1966 through 1993. It concluded that, worldwide, deaths and injuries from burnthrough accidents would be decreased by increasing the ability of airplanes to resist burnthrough.

The Cherry study concluded that -- as of 1999 -- four minutes of additional resistance to burnthrough would result in averting 10.1 fatalities and 13.5 injuries per year over the worldwide fleet of passenger carrying airplanes. Because this final rule requires four minutes of resistance to burnthrough, estimation of benefits from averting deaths and injuries for this evaluation starts with the Cherry estimates. Because these estimates were given in terms of deaths and injuries averted *per* year, this evaluation needed no further adjustment for expected annual occurrence. However, because this rule will apply only to newly produced part 25 airplanes in part 121 service, and not to the worldwide fleet, the FAA adjusted Cherry's 1999 estimates to match the forecast size and increasing effectivity of the affected fleet over the period of implementation, from 2006 through 2021. The components of this adjustment are described below in the discussion of estimating the benefits of averted deaths and injuries.

The estimated annual occurrence of burnthrough accidents to be investigated is derived from an internal database in the Cherry study. This database – on which the study's 1999 conclusions were based -- includes burnthrough accidents that occurred from 1966 through 1993. Thus, these internal data had to be (1) adjusted to match the shorter duration of the period of implementation, (2) brought forward from 1993 and adjusted as above to match the size and effectivity of the part 121 fleet, and (3) to be restated in terms of expected annual occurrence through the period of implementation. These adjustments are described below in the discussion of estimating the benefits of averted costs of accident investigation.

[19] *Fuselage Burnthrough Protection for Increased Postcrash Occupant Survivability: Safety Benefit Analysis Based on Past Accidents*, Cherry, Ray and Warren, Kevin, R.G.W. Cherry and Associates, Ltd., DOT/FAA/AR-99/57 also CAA Paper 99003, September, 1999, Internet access at http://www.fire.tc.faa.gov/pdf/99-57.pdf

Because the Cherry study provides *per*-year estimates of deaths and injuries,[20]this evaluation applies only the fleet effectivity factor in estimating the benefits of averted deaths and injuries. However, because the estimate of averting the cost of accident investigations is derived from a database within the Cherry study -- not from a conclusion of the study – estimating investigation costs requires the use of both the annual expected occurrence and fleet effectivity factors shown in Table B.

The Basis of the Estimate

Benefits of complying with burnthrough requirements can be realized only after an incident or accident has placed the intact hull of a part 25 airplane operated in part 121 service with 20 or more passenger seats into the path of a fuel-fed fire. Even with this rule, such a fire is very highly likely to quickly penetrate through the aluminum skin of the airplane, although not through the required burnthrough resistant insulation.[21] Injuries – and even deaths[22] – may occur.[23] However, the agency assumes that without the rule, the fire will quickly penetrate into the cabin, with the certain result of deaths, injuries and destruction of the airplane hull.

For this evaluation, the FAA assumes this rule will achieve the proportionate (part 121 *versus* worldwide flight) benefits consistent with four minutes of resistance to burnthrough, as estimated in the Cherry study. The agency also assumes the airplane will be lost to further service with or without the rule (destroyed without the rule, and – at the least -- damaged beyond economic repair with the rule).[24] Finally, the agency assumes the cost of investigating a burnthrough accident with the rule is a sixth of the cost without the rule.[25] These elements, discussed in detail below, are the basis of this estimate.

For this estimate, the period of implementation begins with the start year 2006 and goes through 2021. The base-year is 2001 and the 20-year period of analysis is 2002 through 2021. All dollar estimates are in terms of constant 2001 dollars.

Background

[20] Cherry's estimates are for worldwide traffic. This evaluation converts worldwide estimates to part 121 estimates.
[21] This rule requires demonstrated burnthrough resistance of at least four minutes.
[22] NTSB Safety Study: *Emergency Evacuation of Commercial Airplanes*, June, 2000, Findings, p.77. Internet address at http://www.ntsb.gov/Publictn/A_Stu.htm
[23] Deaths, injuries and damage associated with the precipitating event may occur but because they could not be averted by this rule cannot be considered in this evaluation.
[24] The FAA assumes an airplane damaged by burnthrough beyond economic repair has no salvage value.

Resistance to fuselage burnthrough is particularly important in accidents when the fuselage remains intact following a crash. Such an accident occurred in 1985 in Manchester, England, when fuel leakage following an aborted takeoff fed a fire that burned through the intact fuselage of a B-737/200, killing 55 persons who survived the impact of the crash. Following that accident, the FAA began to investigate fuselage burnthrough. The agency determined that enhancement of the thermal acoustic insulation has the most potential for achieving an effective and practical burnthrough barrier. The agency developed a full-scale test method in which a fuselage structure was subjected to jet fuel fires, and with it has investigated a variety of insulating materials. The burnthrough test standards required by this rule will provide a minimum of four minutes of protection against a post-crash fuel fire.

Because the FAA observed that fire penetrated its test rigs along seams where blankets abutted, the agency concluded that not only the material, but also the method of installing the material, is critical to achieving the four-minute standard for burnthrough resistance.[26] FAA technical opinions made available for this evaluation provided an engineering solution to this impediment to meeting burnthrough standards. As discussed below in the section on costs, that solution serves this evaluation as the basis for estimating the costs of complying with burnthrough requirements.

The 1999 Cherry study[27] examined the International Cabin Safety Research Technical Group's Survivable Accidents Database for airplane accidents in which fuselage burnthrough was an issue in the survivability of the occupants. Because the study considered only survivable or potentially survivable burnthrough accidents in which there were fire injuries, its data match the rule requirements that drive this evaluation.[28]

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[25] FAA Office of Accident Investigation (AAI-200) provided this estimate of the incremental difference, May 2002

[26] *Development of Improved Flammability Criteria for Aircraft Thermal Acoustic Insulation: Final Report,* DOT/FAA/AR-99/44, Timothy Marker, U. S. Department of Transportation, September 2000, pp. 39, 43-44. Internet access at http:// www.fire.tc.faa.gov/pdf/99-44/pdf

[27] *Fuselage Burnthrough Protection for Increased Postcrash Occupant Survivability: Safety Benefit Analysis Based on Past Accidents*, Cherry, Ray and Warren, Kevin, R.G.W. Cherry and Associates, Ltd., DOT/FAA/AR-99/57, *ibid*.

[28] *Ibid*, p. one. This study defined a burnthrough accident as: "An aircraft accident where the fuselage skin was penetrated by an external fire while live occupants were on board." A survivable accident is one "where there were one or more survivors or there was potential for survival."

The Cherry study assumed that fewer people would have been injured or killed if the airplanes had been configured to standards expected to replace the standards in effect when the accidents occurred. Thus, the study produced results based on two different assumptions: (1) the airplanes were configured to standards prevailing when the accidents occurred; and (2) the airplanes were configured to the standards expected to replace those in effect during the period of observation (1966 through 1993). Because the burnthrough component of this rule will apply only to newly produced airplanes, the FAA's evaluations are based on the Cherry study conclusions that follow from the later standards.

Estimate of the Benefit of Averting Deaths

Of the 140 worldwide fire related fatal accidents in the International Cabin Safety Research Technical Group's Survivable Accidents Database at the time of the Cherry study, only 54 percent had sufficient data to permit further analysis in that study. However, the authors of that study assumed the data-deficient accidents were similar in benefit potential to those found data-sufficient. This final rule evaluation follows the approach of the NPRM evaluation in accepting that assumption. Thus, this estimate of burnthrough benefits derives from the likelihood of averting the deaths that resulted from all the identified accidents, and not from only those accidents deemed sufficiently data-rich for further analysis in the Cherry study.

The FAA's Technical Center has determined that the burnthrough protection requirements of this rule will provide an additional four minutes for occupants to exit an airplane. The Cherry study showed that four minutes of additional resistance to burnthrough would result in averting 10.1 deaths each year, over the worldwide fleet of passenger carriers.

Because this rule will apply only to newly produced part 25 airplanes in part 121 service, and not to the worldwide fleet, the FAA adjusted Cherry's 1999 averted death estimate downward, as follows:

- On the basis that about 35.1[29] percent of worldwide passenger flight over the period of analysis is expected to be accounted for by part 121 operations, the annual 10.1 worldwide deaths that this rule would have averted had it been in worldwide force in 1999 translate to 3.7 deaths that would have been averted annually by this rule in the base-year (2001), if the rule had been implemented over the entire part 121 fleet.

[29] Derived using *The Airline Monitor*, *ibid*, p. 38, forecast of U.S. vs. World Traffic, and ICAO passenger data.

- Because this rule will apply only to the newly manufactured part 25 airplanes that enter part 121 service, each year's fractional addition to the fleet[30] can avert only a fraction of the 3.7 averted deaths.

- Because the fraction of compliant airplanes is cumulative and starts with 2006, the annual share of potential benefits increases so that 89.8 percent of the affected fleet will be made up of airplanes with burnthrough protection by the end of the 20-year period of analysis.

- the burnthrough estimates are based on Cherry's count of past accidents. That count is adjusted downward to match the shorter period of implementation (16 years *versus* the 28 years Cherry observed) and for expected changes over time of exposure to the risk of a burnthrough accident. The FAA assumes this exposure will escalate during the period of implementation at the same annual average rate as the rate of escalation forecast for the volume of flights controlled by FAA towers. Thus, the annual expected occurrence of averted deaths in 2006 is 4.2.

The steps above produce an estimate of expected deaths this rule will avert each year of the period of implementation (2006 through 2021). To estimate the benefit of averting deaths by complying with burnthrough requirements, each annual total of averted deaths was multiplied by $3,000,000. The resulting values for the years including 2006 through 2021 were converted to constant 2001 dollars, discounted at 7 percent annually to their base-year (2001) values, and summed to produce the total present value of about $50.5 million for the period of analysis. Table E on the next page shows this approach.

[30] Derived using *The Airline Monitor*, *ibid*, pp. 14-15, *and United States Airlines Fleet Forecast 2000 Through 2012*, Greenslet, Edmund S., Verda Beach, Florida. December 2000

TABLE E

MONETIZED BENEFITS OF AVERTING DEATHS BY COMPLIANCE WITH BURNTHROUGH REQUIREMENTS (IN MILLIONS OF CONSTANT 2001 DOLLARS)							
Analysis Period	Calendar Year	Annual New Airplanes (Cumulative)	Potential U. S. Share Of Averted Deaths (Escalated By Rate Of Increase In Flights)	Actual U.S. Share Of Averted Deaths By Proportion Of Compliant Fleet	Benefits From Averting Deaths Constant 2001 Dollars Undiscounted	7% Present Value Factor	Benefits From Averting Deaths Constant 2001 Dollars Discounted
BASE	2001	-	3.7	-	-	1.0000	-
1st	2002	-	3.8	-	-	0.9346	-
2nd	2003	-	3.9	-	-	0.8734	-
3rd	2004	-	4.0	-	-	0.8163	-
4th	2005	-	4.1	-	-	0.7629	-
START	2006	476	4.2	0.3	1.0	0.7130	0.7
6th	2007	978	4.3	0.7	2.0	0.6663	1.3
7th	2008	1499	4.4	1.0	3.1	0.6227	1.9
8th	2009	1989	4.6	1.4	4.1	0.5820	2.4
9th	2010	2489	4.7	1.7	5.1	0.5439	2.8
10th	2011	2990	4.8	2.0	6.0	0.5083	3.1
11th	2012	3488	4.9	2.3	7.0	0.4751	3.3
12th	2013	3978	5.0	2.7	8.1	0.4440	3.6
13th	2014	4457	5.2	3.0	9.1	0.4150	3.8
14th	2015	4931	5.3	3.4	10.1	0.3878	3.9
15th	2016	5402	5.4	3.6	10.9	0.3624	4.0
16th	2017	5868	5.6	3.9	11.8	0.3387	4.0
17th	2018	6332	5.7	4.2	12.6	0.3166	4.0
18th	2019	6792	5.9	4.5	13.4	0.2959	4.0
19th	2020	7249	6.0	4.7	14.2	0.2765	3.9
20th	2021	7702	6.2	5.0	15.1	0.2584	3.9
PRESENT VALUE OF TOTAL BENEFITS FROM AVERTED DEATHS							$50.5

LEGEND:

Money values expressed in 2001 dollars

Policy value for quantified benefit of averted death from *Treatment of Value of Life and Injury in Economic Analysis*, APO-02-1, February 2002

Starting point for estimating expected deaths was *Fuselage Burnthrough Protection for Increased Postcrash Occupant Survivability: Safety Benefit Analysis Based on Past Accidents*, Cherry, Ray and Warren, Kevin, R.G. W. Cherry and Associates, Ltd., DOT/FAA/AR-99/57, September, 1999

Part 121 proportion of Cherry's worldwide count of deaths derived using both Greenslet's *The Airline Monitor,* July 2001, forecast of U.S. vs. World Traffic, and ICAO passenger data.

Proportion of compliant fleet derived using Greenslet's *The Airline Monitor*, July 2001, *and* Greenslet's *United States Airlines Fleet Forecast 2000 Through 2012*, December 2000

Escalation factor adapted from F*AA Aerospace Forecasts, Fiscal Years 2001-2012*, APO-01-1, March 2001

Estimate of the Benefit of Averting Injuries

Both the Cherry study and a recent report by the National Transportation Safety Board note the very high likelihood of averted injury in burnthrough-type accidents. Based on the Cherry study, 13.5 serious and fatal injuries could have been averted had burnthrough protection been in worldwide use in 1999. This evaluation converted the Cherry worldwide estimate of injuries to an estimate of the incremental benefits of averting injuries in part 121 operations followed the approach detailed above for averted deaths, with three exceptions, as follow:

- the total expected annual incidence of injuries expected to result from an accident without the rule was divided equally into four levels of severity of injury, including *serious*, *severe*, *critical* and *died from injuries* (the terminology *died from injuries* is used in this evaluation instead of *fatal injuries*). Consistent with earlier assumptions, this evaluation assumes the annual incidences of levels of severity of injury conform to a uniform distribution (annual occurrence of numbers of accidents varies as did numbers of deaths, above).

- the FAA quantifies policy values of levels of injury severity at $172,500 for *serious injury*; $562,500 for *severe injury*; $2,287,500 for *critical injury*; and $3,000,000 for *died from injuries*.

The resulting annual values were discounted at 7 percent annually to their base-year (2001) values, and summed over the period of implementation to produce the total present value in constant 2001 dollars of about $33.9 million. Table F on the next page shows the results of the approach used to estimate the benefits of the injuries averted by complying with the rule.

TABLE F

MONETIZED BENEFITS OF AVERTING INJURIES BY COMPLIANCE WITH BURNTHROUGH REQUIREMENTS (IN MILLIONS OF CONSTANT 2001 DOLLARS)										
Analysis Period	Calendar Year	Annual Deliveries Of Compliant Airplanes (Cumulative)	U. S. Share Of Potential Averted Injuries (Escalated At Annual Rate Of Increase In Flights) Injury Levels By Policy Values Injury Levels Equally Distributed Across Total				Cumulative Annual Fleet Effectivity	Monetized Values Of Averted Injuries (Un-discounted)	7% Present Value Factor	Monetized Values Of Averted Injuries (Discounted)
			Seriously Injured $172,500	Severely Injured $562,500	Critically Injured $2,287,500	Died From Injuries $3,000,000				
BASE	2001	-	1.2	1.2	1.2	1.2	-	-	1.0000	-
1st	2002	-	1.3	1.3	1.3	1.3	-	-	0.9346	-
2nd	2003	-	1.3	1.3	1.3	1.3	-	-	0.8734	-
3rd	2004	-	1.3	1.3	1.3	1.3	-	-	0.8163	-
4th	2005	-	1.4	1.4	1.4	1.4	-	-	0.7629	-
START	2006	476	1.4	1.4	1.4	1.4	0.0763	0.6	0.7130	0.5
6th	2007	978	1.4	1.4	1.4	1.4	0.1547	1.3	0.6663	0.9
7th	2008	1499	1.5	1.5	1.5	1.5	0.2314	2.0	0.6227	1.3
8th	2009	1989	1.5	1.5	1.5	1.5	0.2980	2.6	0.5820	1.6
9th	2010	2489	1.6	1.6	1.6	1.6	0.3619	3.4	0.5439	1.9
10th	2011	2990	1.6	1.6	1.6	1.6	0.4193	3.9	0.5083	2.1
11th	2012	3488	1.6	1.6	1.6	1.6	0.4775	4.5	0.4751	2.2
12th	2013	3978	1.7	1.7	1.7	1.7	0.5327	5.3	0.4440	2.4
13th	2014	4457	1.7	1.7	1.7	1.7	0.5876	5.8	0.4150	2.5
14th	2015	4931	1.8	1.8	1.8	1.8	0.6323	6.7	0.3878	2.6
15th	2016	5402	1.8	1.8	1.8	1.8	0.6711	7.1	0.3624	2.7
16th	2017	5868	1.9	1.9	1.9	1.9	0.7069	7.9	0.3387	2.7
17th	2018	6332	1.9	1.9	1.9	1.9	0.7359	8.2	0.3166	2.7
18th	2019	6792	2.0	2.0	2.0	2.0	0.7622	8.9	0.2959	2.7
19th	2020	7249	2.0	2.0	2.0	2.0	0.7867	9.2	0.2765	2.6
20th	2021	7702	2.1	2.1	2.1	2.1	0.8146	10.0	0.2584	2.6
PRESENT VALUE OF TOTAL BENEFITS FROM AVERTED INJURIES										$33.9

LEGEND:

Money values are in constant 2001 Dollars

Policy value for quantified benefit of averted death from *Treatment of Value of Life and Injury in Economic Analysis*, APO-02-1, February 2002 Starting point for estimating expected injuries was *Fuselage Burnthrough Protection for Increased Postcrash Occupant Survivability: Safety Benefit Analysis Based on Past Accidents*, Cherry, Ray and Warren, Kevin, R.G. W. Cherry and Associates, Ltd., DOT/FAA/AR-99/57, September, 1999

Part 121 proportion of Cherry's worldwide count of burnthrough injuries derived using both Greenslet's *The Airline Monitor,* July 2001, forecast of U.S. vs. World Traffic, and ICAO passenger data

Proportion of compliant fleet derived using Greenslet's *The Airline Monitor*, July 2001, *and* Greenslet's *United States Airlines Fleet Forecast 2000 Through 2012*, December 2000

Escalation factor adapted from F*AA Aerospace Forecasts, Fiscal Years 2001-2012*, APO-01-1, March 2001

Estimating the Benefit of Averting the Cost of Accident Investigations

The expected benefit of averting investigations of accidents by complying with burnthrough requirements was estimated in two stages: (a) the expected annual incidence of burnthrough accident investigations was estimated, starting from Cherry's count of accidents over the 28 years ended in 1993; and (b) the incremental dollar value of that incidence was estimated.

The steps in developing this estimate of incidence are similar to the steps in estimating incidence for burnthrough deaths and injuries. The principal difference is that this estimate is based on Cherry's count of accidents, not on Cherry's conclusions about averting deaths and injuries. This evaluation assumes the number of accidents equals the number of accident investigations. Steps unique to this estimate are as follow:

- because Cherry's expanded count of accidents was made over 28 years, it was reduced proportionately to fit the period of implementation (2006 through 2021) of 16 years.
- the part 121 share of the count was multiplied by the annual expected occurrence factor (shown in Table B) of 0.063 to produce a single year value. This value, 0.198 (about 1/5), is the estimated annual incidence of averted part 121 burnthrough accident investigations as of 1993 (the final year of Cherry's count). The interpretation is about 1/5 of a burnthrough accident investigation will occur in part 1221 flight, as of 1993.
- the 1993 expected occurrence of accidents was escalated annually from 1993 up to an expected incidence for the base-year 2001 at the same annual rate of growth as for flights controlled at FAA towers during the period 1993-2001. This step results in the annual expectation of 22.8 percent of an accident investigation occurring in the base year 2001. Escalation after 2001 and through 2021 used the same annual growth rate as for accident and injury estimation. By the start year of the period of implementation, the annual expected occurrence of averting the cost of an accident investigation is about 25.6 percent.

The dollar value of the expected benefit of averting the costs of investigating burnthrough accidents by complying with this rule was estimated in much the same way as the expected benefit from compliance with flame propagation requirements. Fleet effectivity remained a factor in each year's estimate. The major differences were: (a) burnthrough requirements are assumed to eliminate all but one-sixth of the cost of the average burnthrough accident investigation;[31] (b) the burnthrough period of implementation begins with 2006, two years further into the period of analysis; (c) the expectation of burnthrough incidence was assumed to vary annually at the same rate of as change in the number of flights controlled by FAA towers; and (d) the estimate of annual incidence is based on multiple occurrences of accidents (not on a single catastrophic accident) over the period of implementation. Converted to constant 2001 dollars and discounted at 7 percent annually, the resulting estimate has the present value of $10.8 million. Table G on the next page shows this approach.

[31] FAA Office of Accident Investigation, *ibid.*

TABLE G

MONETIZED EXPECTED VALUE OF BENEFITS OF AVERTING COSTS OF ACCIDENT INVESTIGATIONS BY COMPLIANCE WITH BURNTHROUGH REQUIREMENTS (IN MILLIONS OF CONSTANT 2001 DOLLARS)				
Analysis Period	Calendar Year	Expected Annual Residual Cost Of Investigations Assuming Potential $5,900,000 Start Year Cost (Escalated at the Annual Rate of Increase in FAA Controlled Flights)	7% Present Value Factor	Expected Annual Value Of Benefits Of Averting Investigation Cost
BASE	2001	-	1.0000	-
1st	2002	-	0.9346	-
2nd	2003	-	0.8734	-
3rd	2004	-	0.8163	-
4th	2005	-	0.7629	-
START	2006	1.3	0.7130	0.9
6th	2007	1.3	0.6663	0.9
7th	2008	1.3	0.6227	0.8
8th	2009	1.4	0.5820	0.8
9th	2010	1.4	0.5439	0.8
10th	2011	1.5	0.5083	0.7
11th	2012	1.5	0.4751	0.7
12th	2013	1.5	0.4440	0.7
13th	2014	1.6	0.4150	0.7
14th	2015	1.6	0.3878	0.6
15th	2016	1.6	0.3624	0.6
16th	2017	1.7	0.3387	0.6
17th	2018	1.7	0.3166	0.5
18th	2019	1.8	0.2959	0.5
19th	2020	1.8	0.2765	0.5
20th	2021	1.9	0.2584	0.5
EXPECTED VALUE OF BENEFITS OF AVERTING INVESTIGATIONS				$10.8

* The expected cost of investigation is adjusted to count only the difference between the cost of investigating an accident with the rule and without it. This adjustment eliminates five-sixth of the cost.

LEGEND:

Money values are in constant 2001 Dollars

Starting point for estimating expected accident investigations was *Fuselage Burnthrough Protection for Increased Postcrash Occupant Survivability: Safety Benefit Analysis Based on Past Accidents*, Cherry, Ray and Warren, Kevin, R.G.W. Cherry and Associates, Ltd., DOT/FAA/AR-99/57, September, 1999

Part 121 proportion of Cherry's worldwide count of burnthrough injuries derived using both Greenslet's *The Airline Monitor,* July 2001, forecast of U.S. vs. World Traffic, and ICAO passenger data

Escalation factor adapted from F*AA Aerospace Forecasts, Fiscal Years 2001-2012*, APO-01-1, March 2001

Estimated Benefit of Compliance with Burnthrough Requirements

The present value of quantified benefits from the burnthrough provisions of the rule are $50.5 million in averted deaths, $33.9 million in averted injuries and $10.8 million in averted costs of accident investigations. These estimated safety benefits total to the present value of about $95.3 million (rounded).

Total Estimated Benefits

The FAA estimates the expected benefits of industry compliance with the flame propagation requirements of this rule will have the present value of about $127.3 million in constant 2001 dollars. Compliance with the burnthrough requirements is estimated to add about $95.3 million to this total. Thus, this rule is estimated to provide expected benefits totaling to the present value of about $222.6 million in constant 2001 dollars.

Estimating Costs

Cost estimates are presented in terms of constant base year (2001) dollars. Each summation of annual values is discounted to its base year value at 7 percent annually.

This evaluation examines four components of cost: (1) the acquisition of test apparatus used to establish the new testing standards; (2) the installation and the maintenance of insulating material to meet the flame propagation requirement; (3) the installation of insulating material to meet the burnthrough requirement; and (4) engineering costs, including those of configuration management, which includes changing (also called "rolling") parts numbers.

Final rule evaluation estimates differ from those of the NPRM evaluation with respect to cost components (1), (2) and (4), as follow:

- the cost of test apparatus was eliminated
- costs of installation and replacement of material for the flame propagation requirement – including the fuel-weight penalty discussed in the benefits section– were added
- the cost of a fuel-weight penalty for burnthrough compliance was added
- the engineering cost of possible changes in design and installation of insulation blankets was eliminated

- engineering costs of configuration management were greatly increased.

Each of the four components of the cost estimate is considered in turn below.

Estimating the Cost of Testing Apparatus

In the NPRM evaluation, the FAA expected that chemical product manufacturers, insulation blanket fabricators and airplane manufacturers, would buy or build as many as 12 of each of the two types of test apparatus (flame propagation and burnthrough) described in the NPRM, at a total industry cost of $673,000 in 2000 dollars.

This final rule evaluation excludes this cost for two reasons: (a) most of the expected 24 apparatus already have been acquired; and (b) almost all of these apparatus were acquired by "up-stream" firms -- like those identified in the NPRM evaluation -- that pass their incremental costs along to be embodied in the added cost of the insulating material acquired by the airplane manufacturer. This final rule evaluation places this added cost in the installation and replacement component. To separately consider the cascade of passed along apparatus costs would be to double count these generally sunk costs.

Estimating the Costs of the Flame Propagation Requirements

This final rule evaluation found that flame propagation requirements will add material costs and fuel-weight penalty costs that were not considered in the NPRM evaluation. While neither installation during manufacture nor replacement during maintenance is expected to add to labor costs, each will add to cost of material and to weight. The additional weight will result in additional fuel cost. Because the additional weight added annually by maintenance-driven replacement of insulating blankets is very slight, this evaluation considers only the fuel cost penalty for blankets installed in newly manufactured airplanes and not for replacement blankets.

For this estimate, the period of implementation begins with the start year 2004 and goes through 2021. The base-year is 2001 and the 20-year period of analysis is 2002 through 2021.

Material Requirements

This rule will increase the cost of blanket cover material for most new part 25 airplanes. Blanket cover material that can meet FAA standards (metalized polyvinylfloride or MPVF) is available for about $2.05[32] per square yard more than the non-compliant material (metalized polyester or MPET) now in use. Further, each square yard of this blanket cover material is about 0.3 of an ounce heavier than the non-compliant material now in use.

For this final rule evaluation, insulating material coverage requirements were received or estimated for 28 models within 13 types of affected large narrow body, large wide body and regional jet airplanes.[33] These are passenger airplanes manufactured under 14 CFR 25 for part 121, 125 and 135 service.[34] This evaluation also estimated coverage requirements for 23 models of executive jets manufactured under part 25 for part 91 service.[35] With minor adaptations approved by their authors, current forecasts used by FAA[36] provided estimates of deliveries for 13 types of passenger airplanes and 23 models of executive jets for each of the 20 years of the period of analysis. For passenger airplanes, insulation coverage requirements by model were averaged into composite values by type to match the formats of the forecasts. For executive jets, the format of their forecast of annual deliveries allowed separate estimation of coverage requirements for each affected model. Because the agency believes that one model of large narrow body airplanes already uses compliant insulating material, costs for that model are excluded from further analysis. Of the 23 models of executive jets, 18 are believed to be already compliant and are excluded from further analysis. The FAA notes that some

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[32] Telephone interviews with cognizant FAA Fire Center staff and with suppliers of cover material.

[33] For example, information provided by a cognizant employee of the Boeing Company and by cognizant employees of material suppliers indicates that the Boeing 737-600, a large narrow body airplane, requires about 2300 square yards of insulating material. This includes a layer on each side of the attenuator material and cap strips over joints. For this evaluation, the FAA assumes the use/loss in fabrication of 20% -- an increase from the 15% assumed in the NPRM evaluation.

[34] Coverage requirements were provided by the manufacturer for 13 models of large narrow body and large wide body airplanes. Coverage requirements for the remaining nine models in these two classes were extrapolated and interpolated using ordinary least squares models. Estimates for six models of regional jets were based on computation of the lateral surface of the cylindrical dimensions of each model. Dimensions were obtained from manufacturers' websites and from *Janes' All The World's Aircraft*, 2000 edition.

[35] Estimates for executive jets also were based on computation of the lateral surface of the cylindrical dimensions of each model. Dimensions were obtained as they were for regional jets.

[36] *United States Airlines Fleet Forecast 2000 Through 2012*, Greenslet, Edmund S., Verda Beach, Florida. December 2000. Adapted according to that author's guidance, and
The Airline Monitor, *ibid* , July, 2001, Also adapted according to the author's guidance; and
Transportation Research Board Forecast for Executive Jets for June 2001. Adapted according to the guidance of Gerald McDougall, Chairman, Light Commercial and General Aviation Committee, Transportation Research Board

manufacturers, particularly of executive jets (and some operators of airplanes required by Airworthiness Directive to be retrofitted with upgraded insulation blanket covers) already are using a covering material (polyimide) that exceeds the requirements of this rule. The agency further notes that in these cases both cost and weight differentials exceed those imposed by the rule. Already compliant airplanes are excluded from this estimate.

This estimate also excludes turboprop airplanes. Although part 25 turboprop airplanes that meet rule criteria are being produced, the FAA notes that much of the very strong growth in the numbers of regional jets is at the expense of turboprop airplanes. In September 2001, 69 turboprop airplanes that meet the flame propagation requirements of this rule were on option or order, with the most distant expected delivery date of 2004. In contrast, 2,146 regional jets that meet the criteria were on option or on order, with the most distant expected delivery date of 2016.[37] Thus, the agency assumes that, over the 20-year period of analysis, the costs of this rule that stem from newly produced turboprop airplanes will be minimal and does not warrant estimation.

Costs of material to meet flame propagation requirements were estimated as follows:

- the incremental cost of \$2.05 per square yard was multiplied by the estimates of coverage for each airplane type or model
- (2) multiplying coverage costs by forecast annual additions to the fleet.

Table H on the next page shows this approach.

[37] Back Aviation Solutions, FleetPC, Version 4.2, run September 2001.

TABLE H

COSTS OF MATERIAL FOR FLAME PROPAGATION REQUIREMENT
FOR ANNUAL PART 25 AIRPLANE PRODUCTION
CERTIFICATED FOR OPERATIONS SUBJECT TO FLAME PROPAGATION RULE PROVISIONS
COSTS IN THOUSANDS OF 2001 DOLLARS

ANALYSIS PERIOD	CALENDAR YEAR	LARGE NARROWBODY		LARGE WIDEBODY		REGIONAL JETS		EXECUTIVE JETS		TOTAL NEW AFFECTED PROD	TOTAL UN-DISCOUNTED COST	TOTAL COST DISCOUNTED AT 7% ANNUALLY
		NEW PROD	COST OF RULE	NEW PROD	COST OF RULE	NEW PROD	COST OF RULE	NEW PROD	COST OF RULE			
BASE	2001	215	-	69	-	151	-	73	-	508	-	-
1st	2002	222	-	63	-	144	-	69	-	498	-	-
2nd	2003	196	-	65	-	147	-	66	-	474	-	-
START	2004	220	522.2	57	427.1	111	212.9	65	75.4	453	1237.7	1010.3
4th	2005	259	606.3	75	576.4	113	215.9	65	74.6	512	1473.2	1123.9
5th	2006	271	620.1	72	563.9	119	226.5	65	72.5	527	1483.0	1057.4
6th	2007	266	614.9	71	549.6	151	290.5	65	73.3	553	1528.3	1018.4
7th	2008	283	628.2	68	537.1	156	298.7	64	72.0	571	1536.0	956.5
8th	2009	258	555.9	77	614.5	141	270.9	64	71.8	540	1513.1	880.7
9th	2010	260	586.3	86	677.7	140	268.9	64	71.5	550	1604.3	872.6
10th	2011	268	583.4	86	702.4	133	255.6	63	77.3	550	1618.6	822.8
11th	2012	277	646.7	75	628.3	132	252.7	63	77.3	547	1604.9	762.5
12th	2013	273	793.0	74	688.5	130	243.2	63	77.3	540	1802.0	800.1
13th	2014	267	776.5	72	674.2	127	238.1	63	77.3	529	1766.1	732.9
14th	2015	264	767.8	71	614.4	126	235.5	63	77.3	524	1695.0	657.3
15th	2016	262	761.4	71	661.1	125	233.5	63	77.3	521	1733.3	628.2
16th	2017	259	754.4	70	654.9	124	231.3	63	77.3	516	1717.9	581.9
17th	2018	258	750.3	70	651.4	123	230.1	63	77.3	514	1709.0	541.0
18th	2019	256	745.5	69	647.2	122	228.6	63	77.3	510	1698.6	502.5
19th	2020	254	740.0	69	642.4	121	226.9	63	77.3	507	1686.6	466.4
20th	2021	253	735.3	68	638.3	120	225.5	63	77.3	504	1676.3	433.2
TOTAL PRESENT VALUE OF COST OF COMPLIANCE												$13,848.6

LEGEND:

Money values expressed in 2001 dollars

Fleet Forecast for Large Narrowbody & Large Widebody:

Greenslet, Edmund S. *Adapted from United States Airlines Fleet Forecast 2000 Through 2012*. Ponte Verda Beach, Florida. December 2000.

Greenslet, Edmund S. Adapted from *The Airline Monitor*. Ponte Verda Beach, Florida. July 2001(adapted per guidance from Edmund Greenslet)

Fleet Forecast for Executive Jets:

Transportation Research Board Forecast Tables for June, 2001.

(adapted per guidance from Gerald McDougall, Chairman, Light Commercial and General Aviation Committee, Transportation Research Board)

Where production forecasts past 2012 were not available, the average annual rate of change for the proceeding 10 years was assumed for years 2013-2021.

Insulation Quantity Assumptions:

Large Narrowbody & Large Widebody

Exact dimensions for 13 models in both categories were obtained. These requirements for each type were extended to the remaining eight using ordinary least squares linear models.

Cost assumptions for flame propagation insulation requirements

Additional $2.05 per square yard

Regional Jets & Executive Jets:

Insulation requirements computed using the lateral surface area of a cylinder, based upon dimensions from manufacturers' websites and *Jane's All The World's Aircraft* (2000 Edition).

Table H shows the estimated present value of the total costs of compliance material for all airplanes added to the affected fleet over the 20-year period of analysis is about $13.8 million. The affected fleet includes passenger jets, including regional jets, and those executive jets that meet the criteria of the rule. However, airplanes already in compliance were excluded from this analysis. Thus, the forecast annual production of 18 of 23 models of executive jets and of one type of passenger airplane was excluded from the estimate.

Cost of Maintenance-Driven Replacement

This rule also requires that flame propagation requirements be met by the thermal acoustic insulating material that is replaced in the fuselage of each airplane manufactured under part 25 and operated under parts 91, 121, 125 and 135. While this maintenance-driven replacement requirement becomes effective on the same date as the installation requirements, it applies to the entire fleet of affected airplanes, and not to the annual supply of newly manufactured airplanes. For the fleet affected by this rule, blanket replacement is most likely to occur during airplanes' heavy maintenance visit. The FAA assumes that for the average airplane across the affected fleet, these visits occur at intervals of about 3.5 years, and that each visit involves the replacement of about 10% of the affected insulating materials.[38] Thus, this evaluation is based on the assumed average annual rate of replacement of about 2.8%.

Because the agency expects the same maintenance-driven labor will be performed whatever the blanket covering, this estimate reflects only the added cost per square yard for the upgraded the material. As noted above, because most models of executive jets are believed to be already compliant, the insulation they use for maintenance-driven replacement also will be compliant, and its cost is excluded from this estimate. Table I, on the next page, shows the expected annual cost of replacing blankets in airplanes manufactured before the effective date of the rule.

[38] August, 2001 telephone interview with cognizant airline maintenance source. Approximated as 10 / 3.5 = 2.8

TABLE I

COST OF MAINTENANCE-DRIVEN REPLACEMENT OF INSULATION FOR PART 25 AIRPLANES CERTIFICATED FOR OPERATIONS SUBJECT TO FIRE PROPAGATION PROVISIONS (COSTS IN THOUSANDS OF CONSTANT 2001 DOLLARS)							
Analysis Period	Calendar Year	Total Forecast Fleet Of Passenger Jets *	Percent Of Fleet Not Already Compliant	Annualized Cost For The Average Airplane	Total Annualized Fleet-Wide Cost Of Replaced Insulation	Present Value Factor	Discounted Cost Of All Replaced Insulation
BASE	2001					1.0000	
1st	2002					0.9346	
2nd	2003					0.8734	
3rd	2004	5910	0.93	0.08	463.1	0.8163	378.1
4th	2005	6164	0.86	0.09	466.9	0.7629	356.2
5th	2006	6242	0.79	0.09	422.7	0.713	301.4
6th	2007	6321	0.72	0.08	378.7	0.6663	252.3
7th	2008	6479	0.65	0.08	338.5	0.6227	210.8
8th	2009	6675	0.59	0.08	331.2	0.582	192.8
9th	2010	6878	0.53	0.09	320.1	0.5439	174.1
10th	2011	7131	0.48	0.09	300.4	0.5083	152.7
11th	2012	7304	0.42	0.09	272.1	0.4751	129.3
12th	2013	7469	0.37	0.10	280.1	0.444	124.4
13th	2014	7585	0.32	0.10	245.3	0.415	101.8
14th	2015	7798	0.28	0.10	213.1	0.3878	82.6
15th	2016	8050	0.24	0.10	198.7	0.3624	72.0
16th	2017	8301	0.21	0.10	178.6	0.3387	60.5
17th	2018	8605	0.19	0.10	163.5	0.3166	51.8
18th	2019	8911	0.17	0.10	149.6	0.2959	44.3
19th	2020	9215	0.14	0.10	135.3	0.2765	37.4
20th	2021	9472	0.12	0.10	116.6	0.2584	30.1
PRESENT VALUE IN CONSTANT 2001 DOLLARS							**$2,752.5**

*NOTE: Excludes Executive Jets. Of the 23 models of executive jets, 18 are believed to be already compliant. Thus, the material used in their maintenance-driven replacement insulation will not change as a result of the rule.

LEGEND:

Money values expressed in constant 2001 dollars

Fleet Forecast for Passenger Jets:

Greenslet, Edmund S. Adapted from *The Airline Monitor*, Ponte Verda Beach, Florida, July 2001 (adapted per guidance from Edmund Greenslet)

Assumptions for replacement:

The average annual rate of replacement of insulation blankets is 2.8%.

Thus, the FAA estimates the flame propagation requirements of this rule applied to maintenance-driven replacement of insulating material will add about $2.8 million (in 2001 dollars) to material costs over the 20-year period of analysis.

Cost of Fuel Required by Additional Weight

As noted above, rule requirements can be met by blanket cover material that weighs 0.3 of an ounce more per square yard than noncompliant material now in use. This amount corresponds to about 22.4 pounds of additional weight for the typical large narrow-body passenger airplane. This additional weight will require additional fuel. The cost estimate for the additional fuel was accomplished as follows:

- multiplying the incremental amount of 0.3 ounces per square yard to the average insulation coverage required by each airplane type or model weighted by its forecast deliveries. This procedure resulted in the estimate of 22.4 pounds added to the average narrow body airplane in the affected deliveries for 2004
- multiplying the average added weight by the forecast of annual hours of flight by class of airplane[39]
- multiplying fuel consumption factors developed by the FAA for use in this type of estimation (0. 005479 for passenger airplanes and 0.005625 for executive jets) by each product of weight *times* hours[40]
- multiplying estimated costs of aviation fuel to each annual product of weight *times* hours *times* fuel consumption factors. [41] The cost of fuel was estimated as follows:
    - by averaging the monthly costs for the 12 months ended April, 2001
    - using that value ($0.7909) as the 2001 base-year fuel cost
    - and escalating the yearly cost for each year of the period of analysis by the same rate – just over 1/3 of 1% -- as the rate of change observed in fuel prices over the years including 1990-2000.[42]

Thus, as Table J on the next page shows, the FAA estimates the weight added by the requirements of this rule will add the present value of about $1.5 million over the 20 year period of analysis. As before, costs for already compliant airplanes were excluded from this estimate.

[39] Adapted from Tables 21 and 26, "U. S. Commercial Air Carriers, Total Airborne Hours, "and "U.S. Regionals/Commuters, Passenger Aircraft and Flight Hours," from FAA Aerospace Forecasts, Fiscal Years 2001-2012, U.S. D.O.T., March, 2001.
[34] The factors are from Tables 7-16 and 7-18 of *Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs,* FAA-APO–98-8, 1998. The tables are from an unpublished section added to the internet version in 1999. The table category "regional jets under 40" seats serves as a proxy for executive jets. The table category used for passenger airplanes is "scheduled commercial service," which includes commuter airplanes.
[41] *The Airline Monitor*, July 2001, *ibid,* p. 51.
[42] *ibid.*

TABLE J

COSTS OF ADDED FUEL FOR ADDED WEIGHT OF INSULATION FOR ANNUAL PART 25 AIRPLANE PRODUCTION SUBJECT TO FLAME PROPAGATION REQUIREMENTS WEIGHTS IN POUNDS PER AIRPLANE – COSTS IN THOUSANDS OF DOLLARS

		PASSENGER JET ANNUALLY ADDED FLEET		EXECUTIVE JET ANNUALLY ADDED FLEET		ADDED FUEL COST FOR AVERAGE WEIGHT ADDED TO AIRPLANES OF ANNUALLY ADDED FLEET	
ANALYSIS PERIOD	CALENDAR YEAR	TOTAL FLIGHT HOURS	ANNUAL AVERAGE ADDED WEIGHT	TOTAL FLIGHT HOURS	ANNUAL AVERAGE ADDED WEIGHT	UNDISCOUNTED	DISCOUNTED
BASE	2001	1150530	24.1	175540	5.1	-	-
1st	2002	1147219	21.2	173726	5.1	-	-
2nd	2003	1082168	21.3	173848	3.7	-	-
START	2004	1019793	20.9	178937	5.0	113.5	92.6
4th	2005	1178834	21.9	184760	5.0	137.9	105.2
5th	2006	1250877	21.5	187781	5.0	143.7	102.5
6th	2007	1361897	20.9	191179	5.0	152.2	101.4
7th	2008	1451093	20.3	184078	5.0	157.7	98.2
8th	2009	1394914	21.1	204862	5.0	157.2	91.5
9th	2010	1446638	21.8	210200	4.9	168.5	91.6
10th	2011	1463129	22.0	212963	4.9	171.9	87.4
11th	2012	1488630	21.9	219857	4.9	174.1	82.7
12th	2013	1525440	25.6	224272	4.9	205.9	91.4
13th	2014	1562977	23.9	228212	4.9	197.0	81.7
14th	2015	1601751	23.5	232790	4.9	198.5	77.0
15th	2016	1641542	24.2	236872	4.9	209.4	75.9
16th	2017	1676910	24.2	241619	4.9	216.5	73.3
17th	2018	1714939	24.3	245846	4.9	222.3	70.4
18th	2019	1747995	24.3	250769	4.9	226.5	67.0
19th	2020	1787957	24.3	255147	4.9	231.7	64.1
20th	2021	1835849	24.3	260250	4.9	237.9	61.5
TOTAL PRESENT VALUE OF COSTS OF COMPLIANCE							**$**1,515.4

LEGEND:

Money values expressed in 2001 dollars

Total flight hours adapted from FAA annual fleet increments

Adapted from *FAA Aerospace Forecasts, Fiscal Years 2001-2012*, March 2001.

Fuel Weight Penalty Assumption:

Added weight is 0.3 ounces per square yard of material.

Fuel consumption factors from FAA APO–98-8, 1998. *Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs* FAA (Unpublished Section 7 added to the Internet version February 1999).

Summary of Material and Operational Costs of the Flame Propagation Requirement

The present value of the cost of the flame propagation requirement is about $18.1 million over the 20-year period of analysis. This total includes about $13.8 million of costs for newly installed material, about $2.8 million of maintenance-driven replacement costs, and about $1.5 million of added fuel costs from added weight.

Estimating the Costs of the Burnthrough Requirements

The burnthrough requirement of this rule applies only to newly manufactured part 25 airplanes with 20 or more passenger seats operated in part 121 service. This requirement becomes effective four years after the rule comes into effect. This requirement has no replacement component, and it applies only to insulating materials installed in the lower half of the fuselage of affected airplanes.

For this estimate, the period of implementation begins with the start year 2006 and goes through 2021. The base-year is 2001 and the 20-year period of analysis is 2002 through 2021.

In the NPRM evaluation, and above in the flame propagation section of this evaluation, the FAA assumed the typical insulation blankets installed in most transport category airplanes generally are composed of three layers of attenuation materials (before this rule, typically fiberglass) encased in a film (before this rule, typically metalized polyester). Although the FAA does not exclude any approach that satisfies its performance requirements, for this evaluation, the agency assumes the burnthrough requirements of this rule bear on the composition and the installation of typical insulation blankets. Thus, costs of blanket materials and costs of engineering are the components of the burnthrough cost estimate.

To estimate the materials component, the NPRM evaluation examined the costs of replacing one of the three layers of fiberglass attenuation material with one layer of a carbon fiber product.[43] That evaluation also examined the cost of using a metalized polyvinylfloride product known to meet the new flame propagation standards for the encasing film. However, the FAA had determined that while these materials did resist burnthrough sufficiently in some tests, they did not when tested in situations that resembled actual installation.

[43] Since the NPRM evaluation, the manufacturer of the carbon fiber product has changed the characteristics of that product and now offers the solution of substituting two layers of the new product for two of the three layers of fiberglass.

Because the agency concluded that the method of installing insulating material is critical to its burnthrough resistance, the NPRM evaluation also included an estimate of costs for design and installation engineering.

Burnthrough cost estimation for this final rule evaluation differs from that for the NPRM evaluation by being based on FAA technical opinions[44] that became available after the completion of the NPRM evaluation. Without being prescriptive, these opinions allowed increased specificity in the cost analysis of burnthrough solutions for the final rule evaluation. This increased specificity allows an approach to compliance that requires no more than minimal costs of design and installation engineering. This final rule evaluation assumes these minimal costs do not warrant estimation. Figure 1, below, shows a common approach to installing insulation blankets.[45] In its tests, the FAA observed this approach to have insufficient burnthrough resistance, even with carbon fiber replacing fiberglass and metalized polyvinylfloride replacing metalized polyester.[46]

Figure 1.

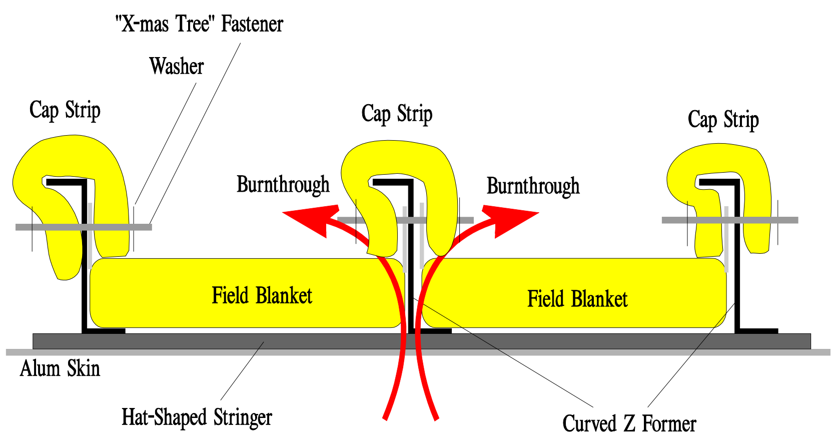

Figure 1 shows a cross-section of insulation blankets (labeled “field blankets”) installed between the formers (or ribs) and against the aluminum skin of an airplane. The two arrows labeled “Burnthrough” show where flame came through this installation. A hard-to-see feature of this drawing is the “ears” or ends of the encasing material that are pulled up into the area shown enclosed by the center “cap strip” and pinned in place by the “X-masTree Fastener” and “Washers.”

FAA technical opinions, including Figures 1 and 2, provided by the Fire Safety Section, Office of Aviation Research. Figure 1 is from *Development of Improved Flammability Criteria for Aircraft Thermal Acoustic Insulation, ibid.,* p. 44

[45] This approach to installation is common in Boeing airplanes. Airbus uses a very similar approach.

[46] The polyimide material noted previously as exceeding rule requirements also failed the installation based tests.

Figure 1 shows fire (indicated by the two large arrows) penetrating the installation along the seams where the insulation blankets (labeled "field blankets") fit against the ribs (labeled "curved Z formers") of the airplane. Because otherwise suitable materials cannot meet burnthrough requirements when installed as shown, engineering costs for design and installation changes necessarily would be incurred, as assumed in the NPRM estimate.

FAA technical opinions state that the method of installation shown in Figure 1 **will** meet burnthrough requirements **if** a layer of ceramic paper is laminated inside the outboard layer (the layer next to the aluminum skin of the airplane) of the metalized polyvinylfloride film encasing the attenuation material -- even without the substitution of carbon fiber for fiberglass.[47] This approach is shown in Figure 2.

Figure 2.

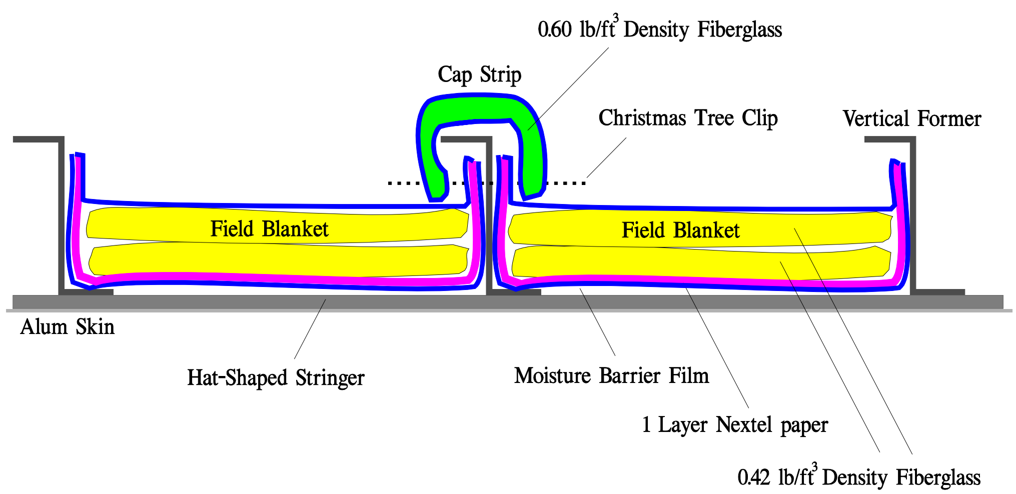

Figure 2 shows the addition of a layer of ceramic paper to the construction of the blanket. As in Figure 1, the "ears" or ends of the encasing film are shown pinned in place within the cap strip enclosure.

Thus, engineering costs will include non-minimal components of design and installation engineering **only if** approaches like that of Figure 1 are maintained. Changing to approaches like that of Figure 2 eliminates these engineering costs.

The FAA is aware of other approaches to installation of insulation that can meet burnthrough

[47] Because the FAA observed that ceramic paper stopped flame but not heat, the agency added an inboard (cold-side) heat standard to the flame penetration standard of this rule. Further tests showed the amount of heat that passed through the ceramic paper was not sufficient to damage interior materials. Source: Fire Safety Section, William J. Hughes Technical Center.

requirements with the substitution of carbon fiber for fiberglass, without using ceramic paper. Use of these other approaches also forestalls the need for design and installation engineering costs. Although the FAA does not exclude any approach (including those that may require non-minimal costs for design and installation engineering) that satisfies its performance requirements, the agency believes the approach shown in Figure 2 will cost less than will redesign of the approach of Figure 1.

Cost Estimate for Burnthrough Material

Based on the information provided in the technical opinions, burnthrough requirements can be met by laminating a layer of ceramic paper to the inside of the outboard side (the aluminum skin side) of the film encasing material. This applies only to the blankets in the lower half of the airplane. Using the material cost of $18.00 per square yard, the estimate was constructed as follows:

- multiplying the incremental cost per square yard by the estimates of coverage for each of the affected airplane types or models,
- adding 20% for material consumed in fabrication, and
- multiplying coverage costs by forecast annual additions to the fleet.

This approach is shown in Table K on the next page. While the table shows the forecast annual numbers of delivered airplanes for each of the 20 years of the period of analysis, cost estimates were made only for the period of implementation, which begins with the start year. Costs for executive jets were not estimated because burnthrough requirements apply only to airplanes operating in part 121 service.

TABLE K

COSTS OF BURNTHROUGH MATERIALS FOR ANNUAL PART 25 AIRPLANE PRODUCTION CERTIFICATED FOR OPERATIONS SUBJECT TO BURNTHROUGH RULE PROVISIONS COSTS IN THOUSANDS OF 2001 DOLLARS										
Analysis Period	Calendar Year	LARGE NARROWBODY		LARGE WIDEBODY		REGIONAL JETS		TOTAL NEW AFFECTED PROD	TOTAL UN-DISCOUNTED COST	TOTAL DISCOUNTED COST
		NEW PROD	COST OF RULE	NEW PROD	COST OF RULE	NEW PROD	COST OF RULE			
BASE	2001	215	-	69	-	151	-	435	-	-
1st	2002	222	-	63	-	144	-	429	-	-
2nd	2003	196	-	65	-	147	-	408	-	-
3rd	2004	220	-	57	-	111	-	388	-	-
4th	2005	259	-	75	-	113	-	447	-	-
START	2006	**271**	1561.0	**72**	912.7	**119**	348.8	462	2822.5	2012.4
6th	2007	266	1544.9	71	917.5	151	429.5	488	2891.8	1926.9
7th	2008	283	1594.3	68	866.5	156	449.3	507	2910.1	1812.2
8th	2009	258	1419.8	77	1029.2	141	402.1	476	2851.1	1659.4
9th	2010	260	1479.1	86	1123.9	140	400.0	486	3003.0	1633.4
10th	2011	268	1382.9	86	1237.6	133	380.2	487	3000.7	1525.4
11th	2012	277	1382.9	75	1067.4	132	382.2	484	2832.5	1345.7
12th	2013	273	1520.2	74	1053.2	130	376.4	477	2949.8	1309.7
13th	2014	267	1486.8	72	1024.7	127	367.8	466	2879.2	1194.8
14th	2015	264	1470.1	71	931.3	126	364.9	461	2766.3	1072.8
15th	2016	262	1458.9	71	1010.5	125	362.0	458	2831.3	1026.2
16th	2017	259	1442.2	70	996.2	124	359.1	453	2797.5	947.6
17th	2018	258	1436.6	70	996.2	123	356.2	451	2789.1	882.9
18th	2019	256	1425.5	69	982.0	122	353.3	447	2760.8	816.8
19th	2020	254	1414.4	69	982.0	121	350.4	444	2746.8	759.5
20th	2021	253	1408.8	68	967.8	120	347.5	441	2724.1	703.9
PRESENT VALUE OF TOTAL COST OF BURNTHROUGH MATERIAL										**$**20,629.6

LEGEND:

Money values expressed in 2001 dollars

Cost Assumptions for Burnthrough Insulation Requirements:

Additional cost is $18.00 per square yard of insulation material

Summary of Material Costs of the Burnthrough Requirement

The present value of the incremental cost of materials required to meet the burnthrough requirement is about $20.6 million (in 2001 dollars) over the 20-year period of analysis.

Cost of Fuel Required by Additional Weight

The addition of a layer of ceramic paper to the film encasing material adds about 2.2 ounces of weight per square yard of coverage. Unlike the coverage of the flame propagation requirements, burnthrough requirements need only one layer, only in the bottom half of the airplane. That amount of coverage adds about 38.6 pounds to the average airplane delivered for part 121 service in 2001.

Estimation of the cost of additional fuel needed for the additional weight added by burnthrough requirements through the period of analysis was accomplished in the same manner as for flame propagation requirements. The principal differences are that executive jets are excluded because burnthrough requirements apply only to part 121 flight, and that the period of implementation starts two years later. Table L, on the next page, shows the estimation procedure.

TABLE L

COSTS OF ADDED FUEL FOR ADDED WEIGHT OF INSULATION FOR ANNUAL PART 25 AIRPLANE PRODUCTION SUBJECT TO BURNTHROUGH REQUIREMENTS WEIGHTS IN POUNDS PER AIRPLANE – COSTS IN THOUSANDS OF 2001 DOLLARS					
ANALYSIS PERIOD	CALENDAR YEAR	PASSENGER JET ANNUALLY ADDED FLEET		ADDED FUEL COST FOR AVERAGE WEIGHT ADDED TO AIRPLANES OF ANNUALLY ADDED FLEET	
		TOTAL FLIGHT HOURS	ANNUAL AVERAGE ADDED WEIGHT	UNDISCOUNTED	DISCOUNTED
BASE	2001	1150530	38.6	-	-
1st	2002	1147219	38.8	-	-
2nd	2003	1082168	38.4	-	-
3rd	2004	1019793	40.4	-	-
4th	2005	1178834	39.9	-	-
START	2006	1250877	38.6	213.0	151.9
6th	2007	1361897	37.4	225.5	150.3
7th	2008	1451093	39.0	251.5	156.6
8th	2009	1394914	49.5	307.9	179.2
9th	2010	1446638	39.6	256.4	139.5
10th	2011	1463129	37.6	247.1	125.6
11th	2012	1488630	40.5	271.8	129.1
12th	2013	1525440	40.5	279.5	124.1
13th	2014	1562977	39.4	279.6	116.0
14th	2015	1601751	40.5	295.6	114.6
15th	2016	1641542	40.5	304.0	110.2
16th	2017	1676910	40.5	311.7	105.6
17th	2018	1714939	40.5	319.9	101.3
18th	2019	1747995	40.5	327.3	96.8
19th	2020	1787957	40.5	336.0	92.9
20th	2021	1835849	40.5	346.2	89.5
TOTAL PRESENT VALUE OF COSTS OF COMPLIANCE					$1,983.2

LEGEND:
Money values expressed in 2001 dollars
Total flight hours adapted from FAA annual fleet increments
Adapted from FAA Aerospace Forecasts, Fiscal Years 2001-2012, March 2001.
Fuel Weight Penalty Assumption:
Added weight is 2.2 ounces per square yard of material.
FAA, *Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Program* (Unpublished Section 7 added to the Internet version February 1999).

Thus, the FAA estimates the weight added by the requirements of this rule will add the present value of about $2.0 million over the 20 year period of analysis.

Summary of Material and Operating Costs of the Burnthrough Requirement

Estimated material and operating costs of compliance with burnthrough requirements is about $22.6 million, including about $20.6 million in material costs and about $2.0 million in added cost of fuel because of added weight. If the total of $22.6 million were incurred in equal annual increments (annualized) over the period of analysis, each increment would be about $2.1 million.

Estimating Engineering Costs for Both Flame Propagation and Burnthrough Requirements

Estimation of engineering costs highlights a difference in terminology between the NPRM evaluation and this final rule evaluation. Both industry and FAA[48] now commonly refer to the management of parts numbers and drawings, including their changes, as “configuration management”-- this evaluation also uses that term in that way. While the NPRM evaluation used the term “configuration changes” to mean “methods of fastening blankets to the fuselage or to each other,” this evaluation expresses that meaning with terms including “design and installation engineering” and “installation methods.”

Another difference, already noted, is that this final rule evaluation is based on standing and incremental fleet counts organized into the categories of large narrowbody, large widebody, regional jets and executive jets. Except for executive jets (and turboprop airplanes as discussed above), the fleets within these categories match the fleets within the categories used in the NPRM evaluation. However, this evaluation equates the category of part 25 airplanes operating as executive jets to the NPRM evaluation category of part 25 airplanes operating in part 91 service. Because the FAA believes manufacturers of most part 25 executive jets already install blankets compliant to flame propagation requirements, and because this category is not subject to burnthrough requirements, this final rule evaluation differs from the NPRM in making no estimate of additional engineering cost for part 25 airplanes in part 91 service.

Flame Propagation Requirements: Configuration Management

The FAA assumes that changing the covers of insulation blankets from metalized polyester (MPET) to a compliant material such as metalized polyvinylfloride (MPVF) will result in costs for the engineering work commonly called configuration management. Thus, new model insulation blankets will be identified by new model nomenclature that will be incorporated into a variety of documents, including drawings, specifications, instructions (in some cases, programmed instructions) and records. Further, because the flame propagation requirements have a maintenance-driven replacement component, the new nomenclature must relate to the archived nomenclature for the pre-rule blankets of out-of-production airplanes.

This final rule evaluation followed the NPRM procedure in developing engineering cost estimates based on numbers of changed documents by airplane type. These estimates do not apply to types of airplanes designed after the effective date of this rule. Those designs will start out with nomenclature for compliant blankets, and thus with no need and no cost for changing documents. The FAA assumes the flame propagation requirement has no component of engineering cost for "methods of fastening blankets to the fuselage or to each other."

While one commenter stated that the FAA's NPRM estimate of engineering costs was greatly overstated, this final rule evaluation finds that the NPRM estimate of configuration management costs was low. Considering other comments and clarifications about the formalization, technical and regulatory requirements and organizational complexity involved in managing aviation parts nomenclature, the FAA revised its NPRM estimate upward.

The agency now accepts the industry assumption that as much as eight hours can be required to fully effect changes in nomenclature for each aviation part involved in compliance. These eight hours make up the time needed for work that begins with the initiation of a change in (or with the introduction of new) nomenclature, and that ends with the completion of the authorized and documented release of that nomenclature to all appropriate holders.[49]

The agency believes this rule will require the affected manufacturers to manage about 48,000 nomenclature changes for airplane types no longer in production but still in service, and about 54,000 for

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[48] See, for example, *FAA Configuration Management Program Plan, Version 1.0*, Brown and Zaidman, January, 2000

[49] The FAA notes this time requirement in part reflects changes in configuration management processes made in response to the findings of a FAA Special Technical Audit conducted in 1999-2000. This audit and its findings were described in *Aviation Week and Space Technology*, November 6, 2000, pp. 43-44. Telephone interviews of cognizant FAA and Boeing personnel suggest that currently observed time requirements will decrease toward the Boeing estimate of eight hours as the new processes mature. The estimate of eight hours is markedly higher than the estimates available for the NPRM evaluation.

airplane types in production and in service.[50] Building on comments and clarifications, the agency assumes that about 30% of the total hours represent the work of aerospace engineers whose fully burdened (salary + benefits + overhead) base-year wage rate is $100/hour. [51] The remainder represents the work of other specialists and support personnel fully burdened at $60/hour. The agency assumes this cost will be split equally between 2002 and 2003. Apart from that allocation over those years, and the necessary discounting to present value, the basic outline of the estimating procedure is as follows:

8 hours ***TIMES*** 111,600 parts ***TIMES*** 0.3 ***TIMES*** $100/hour)
PLUS
8 hours ***TIMES*** 111,600 parts ***TIMES*** 0.7 ***TIMES*** $60/hour)

The present value of total of industry wide configuration management costs for the flame propagation part of this rule totals to about $58.1 million dollars, discounted at 7 per cent annually to the base year 2001.

As configuration management is the largest single expense of the total compliance cost and there is some controversy about how much time is necessary to manage each part, the FAA provides the following simple sensitivity test. The FAA expects the estimated engineering requirements are fairly firm (fixed herein for the sensitivity test). As the FAA-estimated effort is weighted toward support workers, a percent change in the hourly requirement will not result in a similar percent change in total configuration management cost. For those reasons an increase in the total estimated hours per part will result in a less than proportional increase in configuration management cost. For instance, if the total hours per part increase 25 percent to 10 hours, the configuration management cost will only increase by 15 percent. On the other hand, removing the entire support cost and assuming only 2.4 hours per part of engineering time, the total configuration management cost is nearly $25 million in present value. Thus cost of configuration management is relatively insensitive to changes in the hours per part estimate.

[50] Estimates based on Boeing's counts of parts by its types, adjusted upward by dividing production and archived totals by the forecast proportion of Boeing types to all manufacturers' types (further adjusted for Flame Propagation and Burnthrough application). Forecast deliveries adjusted from Greenslet's *Monitor*, *ibid.*, pp-14-15.

[51] This and following related estimates were derived from telephone and email contact with cognizant Boeing representatives.

Burnthrough Requirements

As discussed above, this final rule evaluation assumes the costs of burnthrough requirements include engineering costs expected to result from burnthrough requirements include only the costs of configuration management – design and installation engineering costs were assumed to be so minimal as not to warrant estimation. Following the approach of the NPRM evaluation, burnthrough engineering cost estimates were developed in terms of changes by airplane type. These estimates have no archival component, and they do not apply to airplanes yet to be designed, or to out of production airplanes.

Configuration management costs for burnthrough are expected to bear on about 21,000 parts involved with compliance. Burnthrough configuration management is assumed to begin two years after the effective date of the rule, and to be equally spread over 2004 and 2005. Assuming the same labor allocation as for the flame propagation requirement, the discounted total cost of configuration management for the burnthrough requirement is about $9.6 million in 2001 dollars, over the 20-year period of analysis. The procedure for this estimate is the same as for the estimate of configuration management in support of the flame propagation requirement.

Summary of Engineering Costs: Both Flame Propagation and Burnthrough Requirements

The present value of additional engineering costs needed to meet both flame propagation and burnthrough requirements is about $67.7 million (in 2001 dollars) over the 20-year period of analysis. In each case, the cost results from the work of configuration management. Components of this estimate include about $58.1 million for flame propagation requirements and about $9.6 million for burnthrough requirements.

Comparison of Benefits and Costs

Table M below summarizes the estimated expected benefits and costs of this rule.

TABLE M

ANNUAL PRESENT VALUES OF BENEFITS AND COSTS OF COMPLIANCE WITH THIS RULE (IN THOUSANDS OF CONSTANT 2001 DOLLARS-ROUNDED)										
Period of Analysis	Calendar Year	OVERALL			FLAME PROPAGATION			BURNTHROUGH		
		Benefits	Costs	Net *	Benefits	Costs	Net *	Benefits	Costs	Net *
BASE	2001	-	-	-	-	-	-	-	-	-
1st	2002	-	30.0	(30.0)	-	30.0	(30.0)	-	-	-
2nd	2003	-	28.1	(28.1)	-	28.1	(28.1)	-	-	-
3rd	2004	1.5	6.4	(4.9)	1.5	1.5	0	-	4.9	(4.9)
4th	2005	2.8	6.2	(3.4)	2.8	1.6	1.2	-	4.6	(4.6)
5th	2006	6.2	3.7	2.5	4.1	1.5	2.6	2.1	2.2	(0.1)
6th	2007	8.4	3.5	4.9	5.3	1.4	3.9	3.1	2.1	1.0
7th	2008	10.3	3.3	7.0	6.2	1.3	4.9	4.1	2.0	2.1
8th	2009	11.7	3.0	8.7	6.9	1.2	5.7	4.7	1.8	2.9
9th	2010	12.9	2.9	10.0	7.5	1.1	6.4	5.4	1.8	3.6
10th	2011	13.8	2.8	11.0	7.9	1.1	6.8	5.9	1.7	4.2
11th	2012	14.6	2.5	12.1	8.3	1.0	7.3	6.2	1.5	4.7
12th	2013	15.2	2.4	12.8	8.5	1.0	7.5	6.7	1.4	5.3
13th	2014	15.7	2.2	13.5	8.8	0.9	7.9	6.9	1.3	5.6
14th	2015	16.0	2.0	14.0	8.8	0.8	8.0	7.2	1.2	6.0
15th	2016	16.0	1.9	14.1	8.8	0.8	8.0	7.2	1.1	6.1
16th	2017	16.0	1.8	14.2	8.7	0.7	8.0	7.3	1.1	6.2
17th	2018	15.8	1.7	14.1	8.5	0.7	7.8	7.2	1.0	6.2
18th	2019	15.5	1.5	14.0	8.4	0.6	7.8	7.2	0.9	6.3
19th	2020	15.2	1.5	13.7	8.2	0.6	7.6	7.0	0.9	6.1
20th	2021	15.0	1.3	13.7	8.0	0.5	7.5	7.0	0.8	6.2
PRESENT VALUES		**$222.6**	**$108.4**	**$114.2**	**$127.3**	**$76.2**	**$51.1**	**$95.2**	**$32.2**	**$63.0**

* Parentheses denote negative net amounts.
NOTE: Column totals by year may not sum to summary values in the text because of rounding.

When discounted at 7 per cent annually, the present value of the overall benefits of this final rule is about $222.6 million in constant 2001 dollars. Estimated overall costs are about $108.4 million in 2001 dollars. Thus, taken as a whole, the rule is cost ~~effective~~beneficial. The discounted present values of the benefits of the flame propagation requirements are about $127.3 million, and comparable costs are about $76.2 million. The discounted present values of benefits of the burnthrough requirements are about $95.3 million, and comparable costs are about $32.2 million. Thus, each part of the rule, considered separately, is cost effective. When the net present value of the overall benefit of the rule is annualized or converted into equal annual benefits, it is represented as 20 annual payments each of about $10.8 million.

Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (RFA) establishes "as a principle of regulatory issuance that agencies shall endeavor, consistent with the objective of the rule and of applicable statutes, to fit regulatory and informational requirements to the scale of the business, organizations, and governmental jurisdictions subject to regulation." To achieve that principle, the Act requires agencies to solicit and consider flexible regulatory proposals and to explain the rationale for their actions. The Act covers a wide-range of small entities, including small businesses, not-for-profit organizations and small governmental jurisdictions.

Agencies must perform a review to determine whether a proposed or final rule will have a significant economic impact on a substantial number of small entities. If the determination is that it will, the agency must prepare a regulatory flexibility analysis as described in the Act.

However, if an agency determines that a proposed or final rule is not expected to have a significant economic impact on a substantial number of small entities, section 605(b) of the 1980 act provides that the head of the agency may so certify and an regulatory flexibility analysis is not required. The certification must include a statement providing the factual basis for this determination, and the reasoning should be clear.

The FAA conducted the required review of this final rule, and finds the following:

(1) Engineering and manufacturing costs of this rule apply to manufacturers of part 25 airplanes. No such manufacturer is a small business;

(2) In December 2000, the FAA identified 28 airlines that were small businesses. This evaluation assumes each will replace about 2.8% of the insulation in each of its airplanes with rule compliant insulation annually, on a maintenance-driven basis. Fleet sizes of those 27 carriers still in business range from 2 to 24. The FAA believes the average annual cost of compliance for these carriers will approximate $60 per airplane. Based on fleet size, the annual costs incurred by average small business carrier will approximate $420. This amount is less than an hour of annual operating cost for the airplanes affected by this rule;

(3) Because the FAA believes that manufacturers will pass along their increased compliance costs to the airlines to extent possible, the agency reviewed the scope and significance of these costs from the airlines' point of view. As Table D shows, the discounted present (2001) value of the average airplane newly delivered in 2006 (the first year both flame propagation and burnthrough requirements will be implemented) is about $34.8 million in constant 2001 dollars. Assuming the manufacturer spreads engineering costs (for each requirement) over a 10-year production run, about $12,000 will be added to the cost of the average airplane. Material costs for both requirements will add another $11,000. Thus, about $23,000, or just under seven one-hundredths of one percent is added to the cost of the average airplane that might be acquired by the average small business airline. The FAA believes a small business airline that will acquire, or will secure the use of, a $34.8 million capital asset will neither balk at nor be burdened by this small increment.

Accordingly, pursuant to the Regulatory Flexibility Act, 5 U.S.C. 605(b), the Federal Aviation Administration certifies that this rule will not have a significant economic impact on a substantial number of small entities.

International Trade Impact Assessment

The Trade Agreement Act of 1979 prohibits Federal agencies from engaging in any standards or related activities that create unnecessary obstacles to the foreign commerce of the United States. Legitimate domestic objectives, such as safety, are not considered unnecessary obstacles. The statute also requires consideration of international standards and where appropriate, that they be the basis for U.S. standards.

In accordance with the above statute, the FAA has assessed the potential effect of this final rule and has determined that it will impose the same costs on domestic and international manufacturing entities, and will impose minimal operating costs on domestic operators. The agency believes this final rule will approximate a neutral impact on trade.

Unfunded Mandates Reform Act

Title II of the Unfunded Mandates Reform Act of 1995 (the Act), enacted as Pub. L. 104-4 on March 22, 1995, requires each Federal agency, to the extent permitted by law, to prepare a written assessment of the effects of any Federal mandate in a proposed or final agency rule that may result in the expenditure by State, local, and tribal governments, in the aggregate, or by the private sector, of $100 million or more (adjusted annually for inflation) in any one year. Section 204(a) of the Act, 2 U.S.C. 1534(a), requires the Federal agency to develop an effective process to permit timely input by elected officers (or their designees) of State, local, and tribal governments on a proposed "significant intergovernmental mandate."

A "significant intergovernmental mandate" under the Act is any provision in a Federal agency regulation that would impose an enforceable duty upon State, local, and tribal governments, in the aggregate, of $100 million (adjusted annually for inflation) in any one year. Section 203 of the Act, 2 U.S.C. 1533, which supplements section 204(a), provides that before establishing any regulatory requirements that might significantly or uniquely affect small governments, the agency shall have developed a plan that, among other things, provides for notice to potentially affected small governments, if any, and for a meaningful and timely opportunity to provide input in the development of regulatory proposals.

This rule does not contain any significant Federal intergovernmental or private sector mandate. Therefore, the analytical requirements of Title II of the Unfunded Mandates Reform Act of 1995 do not apply.